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PROCEEDINGS

of the

Indiana Academy *of* Science

Founded December 29, 1885

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Volume 63
1953

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BENJAMIN MOULTON, EDITOR
Butler University
Indianapolis 7, Ind.

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Spring Meeting
May 15-16
SPRING MILL STATE PARK

Fall Meeting
November 6
EARLHAM COLLEGE

Published at Indianapolis, Indiana
1954

1. **Instructions for Authors** appear at end of this volume, p. 284.

2. **Exchanges.** Items sent in exchange for the Proceedings and correspondence concerning exchange arrangements should be addressed:

Indiana Academy of Science, Library
c/o State Library, Indianapolis 4, Indiana

3. **Proceedings** may be purchased through the State Library at $3.00 per volume.

4. **Reprints of technical papers** can often be secured from the authors. They cannot be supplied by the State Library nor by the officers of the Academy.

5. The Constitution and by-laws reprinted from v. 62 and the Membership list reprinted from v. 61, are available to members upon application to the State Library, Indianapolis, Indiana. Necrologies reprinted from the various volumes can be supplied relatives and friends of deceased members by the Secretary.

6. Officers whose names and addresses are not known to correspondents may be addressed care the State Library. The address of the editor of the present volume is Dept. of Geography, Butler University, Indianapolis, Ind.

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OFFICERS AND COMMITTEES FOR 1953

OFFICERS

President.....H. M. Powell, Eli Lilly and Company
Vice-President.....A. H. Meyer, Valparaiso University
Secretary.....W. A. Daily, Eli Lilly and Company
Treasurer...F. J. Welcher, Adult Education Center, Indiana University
Editor.....Benjamin Moulton, Butler University
Press Secretary...J. A. Clark, Department of Conservation, Indianapolis

DIVISIONAL CHAIRMEN

Anthropology.....Paul Gebhard, Indiana University
Bacteriology.....R. L. Thompson, Indiana University Medical Center
Botany.....Daniel Den Uyl, Purdue University
Chemistry.....J. H. Billman, Indiana University
Entomology.....M. Curtis Wilson, Purdue University
Geology and Geography.....Clifford Adams, Hanover College
History of Science.....C. L. Porter, Purdue University
Mathematics.....Arthur Rosenthal, Purdue University
Physics.....R. E. Winn, Indiana State Teachers College
Psychology.....Edward T. Jordan, Indiana State Teachers College
Zoology.....W. H. Johnson, Wabash College

EXECUTIVE COMMITTEE

(Past Presidents, Current Officers, Divisional Chairmen, and Chairmen of Standing Committees)

C. Adams, J. H. Billman, J. A. Clark, N. M. Coats, E. R. Cumings, Mrs. F. K. Daily, W. A. Daily, J. J. Davis, D. Den Uyl, C. C. Deam, Ed. Degering, W. E. Edington, P. D. Edwards, H. E. Enders, P. Gebhard, A. T. Guard, R. N. Harger, W. H. Johnson, T. K. Just, J. S. Karling, R. W. Lefler, Eli Lilly, J. F. Mackell, M. S. Markle, M. G. Mellon, A. H. Meyer, H. H. Michaud, W. P. Morgan, Ben Moulton, F. Payne, C. L. Porter, J. E. Potzger, H. M. Powell, R. R. Ramsey, A. Rosenthal, R. L. Thompson, S. S. Visher, F. N. Wallace, P. Weatherwax, Winona Welch, F. Welcher, M. C. Wilson, R. E. Winn, T. G. Yuncker.

BUDGET COMMITTEE

(President, Secretary, Treasurer, Editor, and Chairmen of Committees on Junior Academy, Library, Program and Relation of Academy to State)

H. M. Powell, W. A. Daily, F. J. Welcher, Ben Moulton, H. H. Michaud, N. M. Coats, M. S. Markle and F. N. Wallace.

COMMITTEES ELECTED BY THE ACADEMY

Trustees of the Academy Foundation (term four years): Chairman, R. N. Harger, Indiana University School of Medicine, Indianapolis (term expires 1956); Ward J. Rice (term expires 1955).

Bonding of Trustees (elected annually): Chairman, R. C. Friesner, Butler University; Scott McCoy.

Research Grants (term five years): Chairman, T. G. Yuncker, DePauw University (term expires 1954); W. H. Johnson (1957), M. G. Mellon (1955), Paul Weatherwax (1956), Mason Hufford (1953), H. M. Powell and W. A. Daily (ex officio).

STANDING COMMITTEES

(Appointed by the President)

Auditing: Chairman, W. P. Morgan, Indiana Central College; S. E. Elliott.

Biological Survey: Chairman, Mrs. Fay K. Daily, Butler University; H. J. Brodie, Franklin Buser, D. G. Frey, H. H. Michaud, Sherman Minton, Winona Welch, Frank Young.

Index: Chairman, Ben Moulton, Butler University; N. M. Coats, F. N. Wallace, Paul Weatherwax.

Indiana Science Talent Search (a sub-committee of the Junior Academy Committee): Chairman, R. W. Lefler, Purdue University; W. H. Welch, L. H. Baldinger, T. W. Torrey, P. D. Edwards, Walter Leckrone (ex officio).

Invitations: Chairman, John S. Karling, Purdue University; R. L. Hicks, J. Mizelle, T. G. Yuncker.

Junior Academy: Chairman, H. H. Michaud, Purdue University; Walter Carnahan, N. E. Adams, R. Niswander, R. McDougal, J. E. Potzger, J. L. Cooprider, P. L. Whitaker, R. E. Martin, R. Cooper, Max Forsyth.

Library: Chairman, N. M. Coats, State Library; W. G. Gingery.

Membership: Chairman, A. T. Guard, Purdue University; M. Burton, J. O. Cottingham, H. E. Crull, M. Garner, W. H. Headlee, R. L. Hicks, Z. D. Hurlbut, W. G. Kessel, E. Kintner, R. Laubengayer, L. S. McClung, A. H. Meyer, D. E. Miller, J. Seybert, A. Strickler, G. T. Wickwire, H. R. Youse.

Necrologist: W. E. Edington, DePauw University.

Nominations: Chairman, Paul Weatherwax, Indiana University; P. D. Edwards, J. F. Mackell.

Program: Chairman, M. S. Markle, Earlham College; Carrolle Anderson, M. R. Garner, R. L. Hicks, R. E. Martin, A. H. Meyer, Ben Moulton, J. E. Potzger, E. Wildman.

Publication of Proceedings: Chairman, Ben Moulton, Butler University; Paul Weatherwax, A. A. Lindsey, P. D. Edwards.

Relation of Academy to State: Chairman, F. N. Wallace, State Department of Conservation; J. A. Clark, H. J. Reed, Eli Lilly.

Representative on Council of the A.A.A.S.: Willis H. Johnson, Wabash College.

Resolutions: Chairman, J. E. Potzger, Butler University; P. D. Edwards, T. G. Yuncker.

Fellows Committee: Chairman, Winona Welch, DePauw University; Glen A. Black, L. S. McClung, F. J. Allen, G. E. Gould, A. H. Meyer, S. S. Visher, P. D. Edwards, J. F. Mackell, F. D. Brooks, W. R. Breneman.

MINUTES OF THE SPRING MEETING

SPRING MILL STATE PARK

SPRING MILL INN, MITCHELL, INDIANA

MAY 15-16, 1953

President H. M. Powell called the Executive Committee Meeting to order at 4:25 P. M. in the Spring Mill Inn.

The officers and committees reported as follows:

Editor. Ben Moulton stated that Vol. 62 of the Proceedings is in page proof and should be distributed in June. The cost of the reprints is to be paid in full by the authors.

P. D. Edwards presented the following motion, "All new members be mailed the Proceedings published during the year in which the members were elected." This was approved.

Press Secretary. James Clark reported that publicity releases had been made to approximately 700 newspapers.

Program Committee. M. S. Markle suggested that titles of papers to be presented at the Fall Meeting be sent in as early as possible.

Membership. A. T. Guard reported 18 applicants for membership.

Biological Survey. Mrs. Fay K. Daily reported that because of the death of Dr. Ray C. Friesner and the severe illness of Dr. C. C. Deam, some duties of the State Flora Committee had been assumed by Dr. J. E. Potzger and Mr. Franklin Buser temporarily until reorganization of the State Flora Committee upon the return to this country of Dr. T. G. Yuncker in the fall.

Old Business.

1. At the suggestion of W. E. Edington, a new committee was appointed by President Powell to erect a John S. Wright memorial plaque in the State Library. The members are John E. Potzger, Chairman; Nellie Coats, W. E. Edington, T. G. Yuncker, and John Seybert.
2. W. A. Daily will present a revision of the "Duties of Officers" at the Fall Meeting.
3. W. A. Daily reported that there is a reasonable possibility of a joint 1954 Spring Meeting of the Indiana and Kentucky Academies.

New Business.

1. It was suggested by B. H. Meyer that we continue having two speakers for the general meeting during the Fall Meeting. There is a possibility that the Society of American Bacteriologists would provide a speaker.
2. Capt. S. V. Cox, Fort Richardson, Alaska, has volunteered to supply biological collections, photographs, etc., to Academy members from the above area.
3. The following motion was presented by Paul Weatherwax, "Research grants of fifty dollars or less are to be made in one payment in full." This was approved.

4. Alton A. Lindsey presented a suggestion that a "Natural Area Preservation Committee" be appointed by the president.

All reports were accepted. The meeting adjourned at 5:30 P. M.

Dinner Meeting. Following the dinner in Spring Mill Inn, the business session was called to order by President Powell in the recreation hall at 7:45 P. M.

1. The applications for membership were approved and accepted.
2. The motion that "all new members be mailed the Proceedings published during the year in which the members were elected" was also accepted.

Following the business session, excellent Kodachrome slides of the spring flora of Southern Indiana were shown by Mrs. Naomi Mullendore Hougham.

Dr. James Thorp of Earlham College then presented an illustrated talk concerning the soils of post-war Japan.

Announcements of field trips to be made the following day were then given. The leaders were: James Cope, J. E. Potzger, C. L. Bieber, Otis F. Starkey, T. M. Bushnell and C. J. Goodnight.

The following telegram was sent to Mr. Charles C. Deam of Bluffton, Indiana: "Sincere greetings and best wishes from the Indiana Academy of Science in session at Spring Mill State Park." W. A. Daily, Secretary.

One hundred and five members signed the Academy roll.

In spite of inclement weather, all scheduled hikes were held Saturday morning.

W. A. DAILY,
Secretary.

MINUTES OF THE EXECUTIVE COMMITTEE

EARLHAM COLLEGE, NOVEMBER 5, 1953

The Executive Committee of the 69th session was called to order by President Powell in Room 205, Dennis Hall, at 7:15 P. M.

The minutes of the Spring Meeting, held at Spring Mill State Park, were read and approved. The reports of officers and committee representatives were presented and accepted as follows:

Treasurer. Report of the Treasurer for the period January 1, 1953, to December 31, 1953.

Receipts

Balance on hand January 1, 1953	$3,770.57
Dues and initiation fees	2,174.00
Publications sold	41.12
Author's reprints Vol. 61	18.00
Author's reprints Vol. 62	506.64
	$6,510.33

Disbursements

1—Editor Vol. 62	$200.00
2—Expenses of Secretary	135.19
3—Expenses of Treasurer	130.83
4—Stationery	124.00
5—Program Committee	333.15
6—Kenneth Wagner research grant	75.00
7—S. S. Visher research grant	50.00
8—L. S. McClung research grant	50.00
9—Fay K. Daily research grant	35.00
10—Binding, Indiana Academy Science Library	697.68
11—Publication of Proceedings Vol. 61	1,830.74
12—Publication of Proceedings Vol. 62	678.62
13—Academy Conference	5.00
14—L. H. Petersen for refund on dues paid in error	8.00
15—Flowers, Charles C. Deam	15.75
16—Expenses to five officers as directed by action of 1947 Executive Committee	100.00
17—Surety bond (three-year term)	62.50
18—Mailing Proceedings	118.08
19—Mailing Author's reprints	15.11
	$4,664.65
Balance on hand Jan. 1, 1954	1,845.68
	$6,510.33

Balance includes $61.30 remaining in treasury from grant for preparation of manuscript of Indiana Scientists.

FRANK J. WELCHER, Treasurer
W. P. MORGAN, Auditor
S. E. ELLIOTT, Auditor

Press Secretary. James Clark reported that the usual press releases were prepared and distributed to newspapers and radio stations in the state.

Editor and Publication of Proceedings. Ben Moulton stated that the Proceedings of the Indiana Academy of Science, Vol. 62, containing 339 pages, was published in June, 1953. The total cost was approximately $4,618.62.

Trustees of the Academy Foundation. In the absence of Chairman Harger, the Secretary reported for the fiscal year 1952-1953:

Assets as of October 1, 1953.....$12,406.00
Cash balance at the Indiana National Bank... 1,157.00

The trustees of the Foundation will invest a proper amount of the cash balance by Jan. 1, 1954.

Bonding of Trustees. The secretary read Scott McCoy's report that the bond covering the treasurer and the trustees has been renewed. The next expiration date is Nov. 18, 1956.

The nominations committee recommended that Scott McCoy continue on the Bonding Committee as chairman and that W. P. Morgan serve as the second member.

Research Grants. T. G. Yuncker reported that there were no applications received for grants. There is a total of $556 in the fund. Any applications received will be carefully considered.

The Nomination Committee recommended that James F. Mackell become a member of the Research Grants Committee.

Auditing Committee. P. D. Edwards suggested that the Auditor's report, prepared after Dec. 31, 1953, be included in these minutes.

Biological Survey. Fay K. Daily reported the activities of members of the committee, and a proposal was made to circulate a questionnaire to all members of the Academy to learn the location and availability of bibliographies and collections in the state and the active workers in this field and to publish the results in the Proceedings of the Academy. The approximate cost was estimated to be about $70.

Fellows Committee. Winona Welch reported that after many hours of study and several meetings, the committee wishes to nominate the following members for the rank of Fellow: W. L. Ayres, I. L. Baldwin, T. F. Barton, I. W. Burr, K. N. Campbell, J. O. Cottingham, Fay K. Daily, H. G. Day, H. E. Driver, F. K. Edmondson, Ned Guthrie, S E. Hartsell, Edith Haynes, Ralph Hull, A. D. Hummel, Floy Hurlbut, J. L. Hyatt, J. S. Karling, H. Koffler, W. L. McAtee, F. C. Mathers, K. W. Meissner, Benjamin Moulton, J. C. Polley, R. L. Shelley, T. M. Sonneborn, O. P. Starkey, K. P. Williams.

Indiana Science Talent Search. R. W. Lefler reported as follows:

Seven regional science fairs were held in Indiana last spring as a follow-up for, and motivating factor for school science fairs in many communities throughout the state. More than 400 student projects were exhibited by some 500 students from 85 Indiana Junior and Senior High Schools.

Fourteen Indiana Senior High School students and their sponsoring teachers were sent to the National Science Fair in Oak Ridge. This con-

stituted the largest group of finalists from any state. Our students won a first place in Biological Sciences and a third place in Physical Science from the twelve awards presented.

Eight regional science fairs will be held in April, 1954. These will be followed in May by the National Science Fair which will be held at Purdue.

All Indiana scientists are invited to the 1953-54 culminating activity of the Indiana Science Talent Search, the Junior Assembly, which will be held at the Claypool Hotel in Indianapolis on March 27, 1954.

Kodachromes were then shown of the work done by participants in the Science Talent Search and the Science Fairs.

Invitations. John S. Karling stated that the Academy has been invited to meet on the Purdue Campus, Nov. 4 to 6, 1954.

Junior Academy. H. H. Michaud reported that:

The twentieth annual meeting of the Indiana Junior Academy of Science was held Saturday, Oct. 18, 1952 in the University Auditorium of Valparaiso University, Valparaiso, Indiana. Over two hundred club members, sponsors, and guests attended the meeting. It was the largest attendance the Junior Academy has recorded at an annual meeting.

There are at present forty-three clubs listed on our roll. At least thirty of these are known to be quite active.

Six new clubs have been added since our last report.

This year's program shows the largest selection of titles ever presented at a Junior Academy meeting.

The Junior Academy has continued to cooperate with the national and state science talent searches and the more recent development of regional science fairs. The latter have received considerable support from newspapers that have helped sponsor local science fairs.

The Indiana Academy of Science should take special note of these activities and should lend its support whenever possible. The State Science Talent Search Committee, under the direction of Prof. R. W. Lefler, is to be highly commended for the splendid work being done in the identification of science talented high school boys and girls and in promoting interest in science.

Library. Nellie Coats reported that ninety-eight serials have been added, making a total of eight hundred two titles currently received. All that began publication in 1950 or later, a date set by the Library of Congress, have been reported for inclusion in that institution's monthly New Serial Titles, a union catalog of continuations in various libraries.

The Proceedings, Volume 62, publication date June 30, 1953, were distributed to members and to institutions, 288 copies going to foreign countries.

Mrs. Harold Burton, Serials Librarian, prepared two hundred twenty-two volumes for binding at an estimated cost of $696.84, actual cost to the Academy $697.68.

Membership. In the absence of Chairman A. T. Guard, A. A. Lindsey stated that there are at this time 32 applicants for membership in the Academy.

Relation of Academy to State. Frank N. Wallace stated that unless otherwise instructed in the near future, he will continue to ask the Indiana Legislature to appropriate $3,500 to aid in the publication of the Proceedings.

Old Business.

Dr. J. E. Potzger, chairman, reported as follows: The John Shephard Wright Memorial Committee had several meetings and discussions to make plans for construction and placing of a plaque to mark the John S. Wright Memorial Library in a fitting manner. It is recommended that an 18 x 8 inch bronze plaque with raised letters be fixed to a 5½ foot walnut standard, to be placed in the junction of corridors marking the entrance to the Academy Library housed in the State Library Building. The total cost will be approximately $100.

Duties of Officers. It was suggested that the revised "Duties," with some additions, be reproduced in an appropriate quantity, but not to be printed in the Proceedings.

New Business.

Five dollars will be sent to the Academy Conference of the A.A.A.S. to aid in defraying office expenses.

The meeting adjourned at 10:10 P. M.

W. A. DAILY,
Secretary

MINUTES OF THE GENERAL SESSION

EARLHAM COLLEGE, NOV. 6, 1953

President T. E. Jones of Earlham College welcomed the Academy to their campus. A response was given by H. M. Powell, president of the Academy.

The minutes of the Executive Committee were read and approved.

W. E. Edington presented a short biography of the members who had died during the year. These were: Clarence E. Baker, George W. Benton, charter member; Philip W. Berg, Charles C. Deam, Ray C. Friesner, Llewellyn V. Ludy, Jasper P. Scott, Karlis Starcs and P. F. Tryon.

T. G. Yuncker gave an illustrated lecture on the subject, "Scenes from the South Pacific."

Dr. D. M. Dack of the Food Research Institute, Chicago, and President of the Society of American Bacteriologists presented a very interesting and stimulating address entitled, "Present Day Problems in Food Poisoning."

The meeting adjourned at 11:15 A. M.

Sectional meetings then began with a recess for lunch served in the campus cafeteria at 12:30 P. M. after which meetings were resumed.

The annual dinner was held in the main floor dining room, Earlham Hall. President Powell introduced guests and the officers of the Academy at the speaker's table.

Dr. Earl Brooks gave a short history of the Indiana Audubon Society.

President H. M. Powell then gave a scholarly address on the subject, "Some Recent Advances in Experimental Chemotherapy."

During the following short business session, A. T. Guard presented the names of 40 applicants for membership. These were duly elected.

J. E. Potzger presented the following resolutions:

1. That the Indiana Academy of Science express sincere thanks to President Thomas E. Jones and faculty of Earlham College for the warm welcome extended to us, and for the many services rendered to make our convention both pleasant and profitable.

2. That special appreciation be expressed to Dr. M. S. Markle, chairman of the program committee, for the efficient manner in which all arrangements, necessary for a successful convention, were made.

3. That we thank the students of Earlham College who aided in making the meetings and plans for dinner and banquet operate so very efficiently.

The Nominations Committee report was given by the Chairman, Paul Weatherwax. Divisional Chairmen for 1954 will be: Anthropology, Thomas B. Noble, Indianapolis; Bacteriology, Dorothy Powelson, Purdue University; Botany, Richard Starr, Indiana University; Chemistry, R. G. Larson, Valparaiso University; Entomology, Paul T. Ulman, Noblesville; Geology and Geography, Benjamin Moulton, Butler University; History of Science, M. S. Markle, Earlham College; Mathematics, Ralph Hull,

Purdue University; Physics, George D. Van Dyke, Earlham College; Zoology, John D. Mizelle, University of Notre Dame.

The following members were recommended to serve as the 1954 officers: President, O. B. Christy, Muncie, Indiana; Vice-President, Raymond Girton, Purdue University; Secretary, W. A. Daily, Eli Lilly and Company; Treasurer, Frank Welcher, Indiana University Education Center, Indianapolis; Editor, Benjamin Moulton, Butler University; Press Secretary, J. A. Clark, Department of Conservation, Indianapolis.

The sixty-ninth annual meeting of the Indiana Academy of Science with a general attendance of 430 and a dinner attendance of 123 was adjourned.

W. A. DAILY,
Secretary.

NEW MEMBERS 1953[1]

Agnita, Sister Mary, S.P., Clinton and Lewis Sts., Fort Wayne, Ind. C
Allmon, Ross H., 4201 N. Clarendon Ave., Chicago 13, Ill. E
Ash, Charles R., 3741 Second St., Riverside, Cal. E
Barton, James D., Jr., 130 Marstellar St., West Lafayette, Ind. Bo
Becht, Dr. J. Edwin, 208 S. Union St., Bloomington, Ind. G
Brooks, C. Reid, R. R. 1, Greens Fork, Ind. G, Z
Bunce, George W., 443 N. Cline, Griffith, Ind. Bo, Z, C
Cameron, Donald K., Jr., Box 33, Roger's Center, Bloomington, Ind. G
Celine, Sister M., O.S.F., St. Francis Col., 2701 Spring St., Fort Wayne, Ind. Bo, Z
Cleveland, Merrill L., 11-10 Ross Ade Dr., West Lafayette, Ind. E
Correll, Prof. Malcolm, 422 Anderson St., Greencastle, Ind. Ph
Coulter, Nancy M., Y.W.C.A. Residence, 802 N. Lafayette Blvd., South Bend, Ind. C
Deal, Prof. Duane E., Ball State Teachers College, Muncie, Ind. M
Doeden, Gerald E., 703 Franklin St., Valparaiso, Ind. C
Drummond, Roger O., Dept. of Zoology, Univ. of Maryland, College Park, Md. Z
Eaton, Dr. Scott V., Lincoln Hills, R. R. 4, Valparaiso, Ind. Bo
Elder, Dr. F. Kingsley, Jr., Physics Dept., Wabash College, Crawfordsville, Ind. Ph
Ellis, Dr. Nathan Kent, Dept. of Horticulture, Purdue University, West Lafayette, Ind. Bo
Fields, Marion Lee, 1036 Chestnut St., Columbus, Ind. Bo
Friedman, Samuel A., Indiana State Geol. Sur., Indiana University, Bloomington, Ind. G
Funderburg, John Arthur, R. R. 5, Huntington, Ind. M
Glenn, A. H., A. H. Glenn and Assoc., 111 New Orleans Airport, New Orleans 22, La. G
Goldthwaite, Marion, 210 Berkeley Rd., Indianapolis, Ind. Ba
Gordon, William R., Jr., Lincoln H. S., Cambridge City, Ind. Bo, Z
Goss, Robert C., F.P.H.A. 517-4 Airport Rd., West Lafayette, Ind. Bo
Guthrie, Frank A., 108 Monroe Blvd., Terre Haute, Ind. C
Haldar, Dr. Barun Chandra, Dept. of Chemistry, Notre Dame University, Notre Dame, Ind. C
Heise, John J., R. F. D., Paoli, Ind. C
Hennings, Prof. George, 526 N. Martin St., Muncie, Ind. Bo
Huelsman, Benjamin R., 408 N. Grant St., Bloomington, Ind. A
Hults, Malcom Eugene, 3007 Ethel Ave., Muncie, Ind. Ph
Jones, Dr. G. Neville, Dept. of Botany, Univ. of Illinois, Urbana, Ill. Bo
Jordan, Prof. Edward T., 524 S. 5th St., Terre Haute, Ind. Ps
Kilduski, Robert J., 617 213th Pl., Dyer, Ind. E
Kyle, Robert K., 440 School St., Culver, Ind. Ba, Bo, H, Z

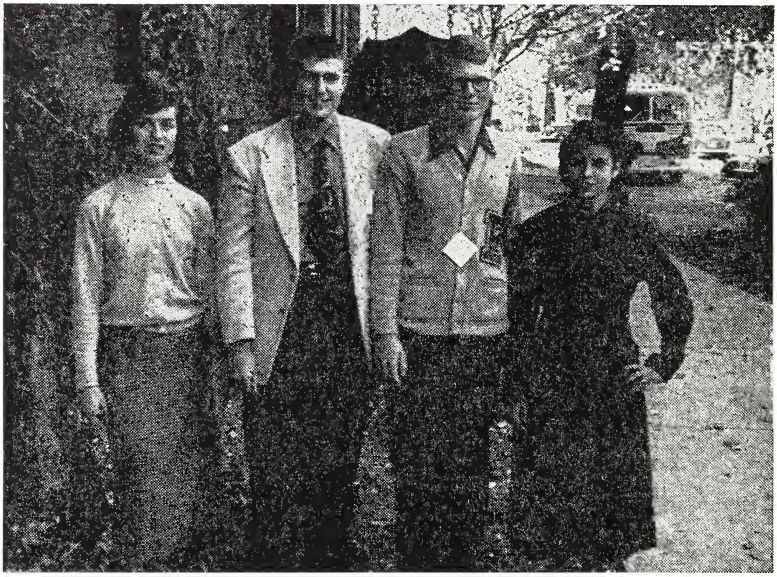
[1] Abbreviations following the members' listings indicate the section of the Academy with which they are affiliated.

Ledwell, Mrs. Shirley F., 3724 S. Washington St., Marion, Ind. Ba
Lehker, Prof. Glen E., 473 Littleton St., West Lafayette, Ind. E
Leighly, Prof. Hollis P., Lawrenceville, Ill. C, G
Leopold, Dr. A. Carl, Horticulture Dept., Purdue University, Lafayette, Ind. Bo
Liming, Alfred Newton, 762 West St., Versailles, Ind. Bo
Lingappa, B. T., Dept. Biol. Sci., Purdue University, Lafayette, Ind. Bo
McKenna, Dr. Frank S., 314 Arlington Ave., Greencastle, Ind. Ps
McMackin, Mrs. Sarah F., 4308 S. Harmon St., Marion, Ind. Ba
MacFarlane, Dr. John O., Eli Lilly and Co., Indianapolis, Ind. Ba
Maffet, Vere, Ross Ade Drive, Bldg. 1, Apt. 11, West Lafayette, Ind. C
Magoon, Dr. Wallace, Ball State Teachers College, Muncie, Ind. Z
Miller, Brinton M., 204 Perrin Ave., Lafayette, Ind. Bo
Moore, Doxie, 2043 S. 9th St., Lafayette, Ind.
Mozen, Milton M., Col. of Agriculture, Dept. of Bio-chemistry, Univ. Wisconsin, Madison 6, Wis. C
Mumford, Russell E., R. R. 1, Cortland, Ind. Z
Murray, Dr. Haydn H., Dept. of Geology, Indiana University, Bloomington, Ind. G
Naugle, Jack E., 417 E. Main St. (Levee), West Lafayette, Ind. E
O'Brien, Mrs. Gladys, 410 N. Chester, Indianapolis, Ind. G
Oster, Irwin I., 1603 E. 3rd St., Bloomington, Ind. Z
Overlease, William R., 1820 Stevens Ave., Elkhart, Ind. Bo, G, Z
Pelton, Mrs. Jeanette S., 411 Buckingham Dr., Indianapolis, Ind. Bo
Pelton, Dr. John F., Dept. of Botany, Butler Univ., Indianapolis, Ind. Bo
Pfaff, Richard Lee, 44 S. 21st St., Richmond, Ind. G
Platt, Dr. Charles E., 309 Harrison Hall, DePauw University, Greencastle, Ind. Ps
Plummer, Gayther L., Dept. of Biol. Sci., Purdue University, West Lafayette, Ind. Bo
Pray, Dr. Enos G., Hanover, Ind. Z
Proctor, Mrs. Berdine R., 4726 E. Washington St., Indianapolis, Ind. Bo, Z
Reitz, Dr. Henry C., R. R. 10, Lafayette, Ind. C
Repaske, Dr. Roy, Dept. of Bacteriology, Indiana University, Bloomington, Ind. Ba
Richey, Gilbert T., Jr., 1850 N. Whittier Pl., Indianapolis, Ind. C
Ricketts, Dr. John A., 3 Observatory Hill, Greencastle, Ind. C
Riely, Samuel L., Dept. of Geology, Indiana Univ., Bloomington, Ind. G
Scarborough, Dr. Barron B., DePauw University, Greencastle, Ind. Ps
Shiner, Dr. V. J., Jr., 111 N. Dunn St., Bloomington, Ind. C
Sinski, James T., 420 Hayes, West Lafayette, Ind. Bo
Starcs, Mrs. Helene, 2915 Guilford, Indianapolis, Ind. Bo
Starr, Dr. Richard C., Dept. of Botany, Indiana University, Bloomington, Ind. Bo
Strickler, Dr. Paul M., Indiana Central Col., Indianapolis 27, Ind. Ph
Stuck, Mrs. Dollie N., 1309 N. Pennsylvania St., Indianapolis, Ind. Bo
Sutter, Delos M., 222 Douglas Ave., Kalamazoo, Mich. Ph
Swinehart, Bruce A., 509 Evergreen St., West Lafayette, Ind. C
Telfair, Dr. David, Earlham College, Richmond, Ind.

Thanos, Dr. Andrew, Dept. K-490, Eli Lilly & Co., Indianapolis, Ind. Bo
Thomson, William E., 128 Stirton St., Hamilton, Ontario, Canada G
Thorp, Prof. James, Earlham College, Richmond, Ind. G
Tolman, Robert A., 701 N. Dunn St., Bloomington, Ind. Z
Wahl, Lucille, 941 Hervey St., Indianapolis, Ind. Bo
Welcher, Mrs. Frank J., R. R. 12, Box 242W, Indianapolis 44, Ind. Z
Wilson, Kenneth S., F.P.H.A. 206-4 W. State St., W. Lafayette, Ind. Bo
Woerner, Dr. Dale E., Hanover College, Hanover, Ind. C
Wood, Elmo S., Box 14, New Castle, Ind. C, Bo
Wood, Joseph M., Dept. of Botany, Indiana Univ. Bloomington, Ind. Bo
Zlab, Dennis K., 309 Sheridan Ave., Crawfordsville, Ind. Bo

Junior Academies

Albertus Magnus Science Club, Central Catholic H. S., Clinton and Lewis, Fort Wayne, Ind. C, Ph
Griffith H. S. Science Club, 202 Broad St., Griffith, Ind. Bo, Z, Ph, C
Junior Explorers of Science, Lebanon H. S., Lebanon, Ind. Bo, Z, Ph, C
Biology Club, Martin Boots Jr. H. S., Grade 9, 715 W. 3rd St., Marion, Ind. Bo, Z



INDIANA JUNIOR ACADEMY OF SCIENCE OFFICERS FOR 1953

From left to right: Gail Diamondis, South Bend, Press Secretary; Don Lambdin, Elkhart, Vice-President; David Stevenson, Fort Wayne, President; Mina Zaldivar, Gary, Secretary.

INDIANA JUNIOR ACADEMY OF SCIENCE

OFFICERS FOR 1953

PRESIDENT: David Stevenson, Phy-Chem Club, Elmhurst H. S., Ft. Wayne.

VICE-PRESIDENT: Don Lambdin, Junior Academy, Elkhart H. S., Elkhart.

SECRETARY: Mina Zaldivar, Biology Club, Lew Wallace H. S., Gary.

PRESS SECRETARY: Gail Diamondis, Junior Academy, Central H. S., South Bend.

MEMBERS OF THE COUNCIL: Max Forsyth, Indianapolis (1949-1953); Harold Stewart, Bloomington (1950-1954); Arthur L. Smith, South Bend (1951-1955); Charles E. Karst, Mishawaka (1952-1956); Edith Wallace, Gary (1953-1957).

PROGRAM OF THE TWENTY-FIRST ANNUAL MEETING

November 7, 1953

Dennis Science Hall

Earlham College, Richmond, Indiana

8:00-10:00 a. m. Exhibits, Dennis Science Hall, Rooms 114, 120.

10:00 a. m. Morning Session, Auditorium, Dennis Science Hall.

General Session. David Stevenson, presiding.

Reading of the minutes of the 1952 meeting, Mina Zaldivar, Secretary.

Greetings, Gene Chenoweth, President, Earlham College Senate.

Papers:

Albertus Magnus Science Club, Central Catholic H. S., Fort Wayne:

1. Alumina Chromatography, Patrick Ledden.

National Scientific Honor Society, Bloomington H. S., Bloomington:

2. Fluorescence of Minerals, Joseph Moser.
3. Fundamentals of Electron Tubes, Robert Joseph Strain.
4. Bacteriology, John Costas.

Adams Walton Club, John Adams, H. S., South Bend:

5. What Happened to Charlie?, James Dincolo.

Science Club, Calumet H. S., Gary:

6. Collecting Turtles of Indiana, Jerry Shaffer.

Naturalist's Club, Shortridge H. S., Indianapolis:

7. Illustrating the Theory of Bird Flight, Shelia Brantlinger.

Science Club, Howe H. S., Indianapolis:

8. Amphibians of Indiana, Larry Kinsey.
9. Tissue Cultures, James Barnes.
10. Culture of Fern Prothalia, Ronnie De Langlade.
11. Microdissection of Daphnia, Joan Brown.
12. Mycology, Bob Little.

12:15 p. m. Noon Luncheon, Earlham College Cafeteria.

1:15 p. m. Afternoon Session, Auditorium, Dennis Science Hall.

Business Session.

Science Club, Howe H. S., Indianapolis:

13. Medical Mycology, Dick Slaughter.
14. Astronomy, Bill Crawley.
15. Raising of Cecropia Moths, Terry Hankins.
16. Ecological Survey of Ellenberger Park and Pleasant Run Parkway, Kent Stewart and Dave Harvey.
17. The Effect of X-Ray on Tomato Seedlings, Elizabeth Tincher.

Central Junior Academy, Central H. S., South Bend:

18. Relativity of the Atom, Arthur H. L. From.
19. The General Nature of Amino Acids, Ruth E. Falk.
20. A Study in the Behavior of Hamsters, Rita Payton and Patricia Price.

Science Club, Valparaiso H. S., Valparaiso:

21. Paper Chromatography, Mary Anne Miller.

Junior Academy of Science, Elkhart High School, Elkhart:

22. The Construction of Simple Binary Relay Computing Machines, Frederick Blackwell.

Science Club, University H. S., Bloomington:

23. A Study of the Fish Life of Selected Streams and Lakes of Indiana, John Clayton.
24. Techniques of Cave Exploring, Science Club Members.
25. My Experience at the National High School Institute Program in the Engineering Class, Esther Irwin.

Biology Club, Lew Wallace H. S., Gary:

26. Reptiles (illustrated), Bill Mitchell.

Science Club, New Castle H. S., New Castle:

27. Some Interesting Findings from High Voltage Experiments, Thor Semler.

MINUTES

The twenty-first annual meeting of the Indiana Junior Academy of Science was held Saturday, November 7, 1953 in the auditorium of Dennis Science Hall, Earlham College, Richmond, Indiana.

The exhibit room opened at 8:00 a. m. in rooms 114 and 120 in the Science Hall. A total of eighteen science projects were displayed by the club members.

The general session was called to order at 10:15 a. m. by President David Stevenson, Phy-Chem Club, Elmhurst H. S., Fort Wayne. The president introduced the other officers, Vice-President, Don Lambdin, Junior Academy, Elkhart H. S., Elkhart, and the Secretary, Mina Zaldivar, Biology Club, Lew Wallace H. S., Gary

The minutes of the 1952 meeting were reviewed by the Secretary. Gene Chenoweth, President of the Earlham College Senate, welcomed all members and friends of the Junior Academy of Science in behalf of the college.

Patrick Ledden, Albertus Magnus Science Club, Central Catholic H. S., Fort Wayne, opened the morning program of student papers with a talk on "Alumina Chromatography."

"Fluorescence of Minerals" was the topic presented by Joseph Moser, National Scientific Honor Society, Bloomington H. S., Bloomington. His demonstration of laboratory materials added considerable value to his paper.

Robert Joseph Strain, National Scientific Honor Society, Bloomington, spoke on the "Fundamentals of Electron Tubes." It was a fascinating subject and John's drawings illustrated the talk very well.

"Bacteriology" was the next subject presented by John Costas, National Scientific Honor Society, Bloomington. John's discussion showed that he had done considerable work in bacteriology.

John Dincolo, Adams Walton Club, John Adams H. S., South Bend, next gave an interesting and amusing account of "What Happened to Charlie?" Charlie was a lion that had to be poisoned because he became too difficult to handle. The incident resulted in a project of taxidermy for the Walton club members which was pleasantly recorded in kodachrome slides.

Shelia Brantlinger, Naturalist's Club, Shortridge High School, Indianapolis, followed with an illustrated talk on the "Theory of Bird

Flight." She explained the mechanics of flight and some of the bird's adaptations for flight.

A discussion on "Amphibians in Indiana" was given by Larry Kinsey, Science Club, Howe H. S., Indianapolis. He explained how experiments were conducted on artificial hibernation.

James Barnes, Science Club, Howe H. S., explained how he became interested in the subject of "Tissue Cultures," and the "Culture of Fern Prothalia" was presented by Ronnie De Langlade, also of the Science Club of Howe H. S.

The last two topics on the morning session were given by Joan Brown, on "Microdissection of Daphnia" and by Bob Little on "Mycology." Both students are members of the Science Club, Howe H. S.

The morning session was adjourned at 12:05 p. m. by President David Stevenson. Luncheon was served at the College Cafeteria.

The afternoon session was called to order at 1:15 p. m. by David Stevenson. The first item of the business meeting was the election of officers. A slate of officer candidates was submitted by the council and additional nominations were accepted from the floor. The following officers were elected for 1954: President, James Dincolo, Adams Walton Club, John Adams H. S., South Bend; Vice-President, Larry Kinsey, Science Club, Howe H. S., Indianapolis; Secretary, Janet Golba, Adams Walton Club, John Adams H. S., South Bend.

The afternoon program of student talks was opened by the following members of the Science Club, Howe H. S., Indianapolis: Dick Slaughter spoke on "Medical Mycology," Bill Crawley on "Astronomy," Terry Hankins on "Raising of Cecropia Moths" and Elizabeth Tincher on "The Effect of X-Ray on Tomato Seedlings."

Students of the Central Junior Academy, Central H. S., South Bend, presented papers as follows: Arthur H. L. From presented a discussion on the "Relativity of the Atom," Ruth E. Falk on "The General Nature of Amino Acids," and Rita Payton and Patricia Price on "A Study in the Behavior of Hamsters." The latter talk was especially interesting to the audience. A live hamster was used to show how it had learned to take food from a bottle by pulling on a string that was tied to the food.

Mary Anne Miller, representing the Science Club of Valparaiso H. S., Valparaiso, gave a talk on "Paper Chromatography."

"The Construction of Simple Binary Relay Computing Machines" was the topic given by Frederick Blackwell, Junior Academy of Science, Elkhart H. S., Elkhart. He explained the parts of a computing machine and how computers use the binary subtraction and addition systems.

The following speakers represented the Science Club, University H. S., Bloomington: John Clayton spoke on "A Study of the Fish Life of Selected Lakes and Streams of Indiana." Several Science Club members spoke on various phases of "Techniques of Cave Exploring," and Esther Irwin on "My Experience at the National High School Institute Program in the Engineering Class."

Bill Mitchell, Biology Club, Lew Wallace H. S., Gary, presented an illustrated talk on "Reptiles."

The concluding talk on "Some Interesting Findings from High Voltage Experiments" was presented by Thor Semlar, Science Club, New Castle H. S., New Castle. Thor showed several interesting experiments with the use of high voltage.

Professor Howard H. Michaud, Department of Forestry, Purdue University and State Sponsor of the Junior Academy of Science, reported on the progress of the high school science clubs in the state, and on the importance of the state-wide science activities of the past year. Special mention was made of the new clubs for 1953 which included the following: Junior Explorers of Science, Lebanon H. S., Lebanon, Miss Helen E. Reed, Sponsor; Biology Club, Martin Boots Junior H. S., Marion, Mr. John Clevenger, Sponsor; Science Club, Griffith H. S., Griffith, Mr. George Bunce, Sponsor; and the Albertus Magnus Science Club, Central Catholic H. S., Fort Wayne, Sister Mary Agnita, Sponsor.

The importance of the National and Indiana Science Talent Searches was emphasized. Professor Michaud stated that eighty-five of the eighty-eight students who entered the science talent search last year are at present attending college. He mentioned that the Junior Academy also cooperates in sponsoring the regional science fairs which were started in Indiana last spring.

It was announced that Miss Jerry Motley, Sponsor, Science Club, Howe H. S., Indianapolis, was elected new council member to succeed Mr. Max Forsyth of Indianapolis whose term expired in 1953.

Joseph Moser, National Scientific Honor Society, Bloomington H. S., Bloomington, was chosen as "best boy" and Joan Brown, Howe H. S., Indianapolis, was named "best girl" in science for 1953. David Stevenson, Elmhurst H. S., Fort Wayne, and Mary Anne Miller, Valparaiso H. S., Valparaiso, received honorable mention. The winners of these awards are selected on the basis of information about each student submitted by sponsors of the Junior Academy clubs. Those who achieve this honor are given a year's membership in the American Association for the Advancement of Science.

More than forty high school science clubs are affiliated with the Indiana Junior Academy of Science. The twenty-first annual session at Earlham College was the most successful meeting ever enjoyed by the Junior Academy. There was greater participation, more interest, and a larger attendance than in any previous year. Two hundred and fifty students, teachers and guests were registered.

The Junior Academy will meet at Purdue University for its twenty-second annual session on November 6, 1954.

After expressing his thanks to all who participated in the program, to Earlham College and to all who attended, President David Stevenson adjourned the 1953 meeting.

EXHIBITS

Antibiotics; Fluorescence of Minerals: National Scientific Honor Society, Bloomington H. S., Bloomington.

Spelunking Equipment; Fish Display: Science Club, University H. S., Bloomington.

Insect Collection: Junior Academy of Science, Elkhart H. S., Elkhart.

A Study of Loci; Method of Delaying Sound; Model Paper Mill: Phy-Chem Club, Elmhurst H. S., Fort Wayne.

Reptiles: Biology Club, Lew Wallace H. S., Gary.

Raising Cecropia Moths; Medical Mycology; Ecological Survey of Ellenberger Park and Pleasant Run Parkway: Science Club, Howe H. S., Indianapolis.

Insect Collection: Naturalist's Club, Shortridge H. S., Indianapolis.

Cactus Collection; 3-Dimension; Staining and Clearing Small Animals: Science Club, Richmond Senior H. S., Richmond.

Behavior of Hamsters: Junior Academy of Science, Central H. S., South Bend.

Oil Fractional Column: Science Club, Valparaiso H. S., Valparaiso.

INDIANA JUNIOR ACADEMY OF SCIENCE CLUBS
FALL 1953

Town	*School and Club*	*Sponsor*
1. **Attica**	H. S., Sci-Math. (1949)	J. Claude Daugherty
2. Bedford	H. S., Science, (1951)	Elmer Wright
3. Bloomington	H. S., National Scientific Honor Society, (1931)	Harold Stewart
4. Bloomington	University H. S., Junior Academy, (1938)	Robert Carpenter P. L. Whitaker
5. Clayton	H. S., Junior Academy, (1951)	Howard C. Lewis
6. Crawfordsville	H. S., Up-N-Atom, (1950)	David Wells
7. Elkhart	H. S., Junior Academy, (1940)	Evelyn Wagoner
8. Fort Wayne	Central H. S., Nature, (1940)	Iva Spangler
9. Fort Wayne	Central Catholic H. S., Albertus Magnus Science Club, (1952)	Sister Mary Agnita, S.P.
10. Fort Wayne	Elmhurst H. S., Phy-Chem (1935)	Ruth Wimmer
11. Fort Wayne	North Side H. S., Nature, (1952)	Vesta Thompson
12. Gary	Calumet Twp. H. S., Science, (1952)	Mrs. Catherine Dale
13. Gary	Edison H. S., Beaker Breakers, (1949)	Mrs. Martha B. Connor
14. Gary	Lew Wallace H. S., Biology, (1935)	Lola Lemon
15. Gary	Lew Wallace H. S., Klub Kem, (1941)	Mrs. Helen McKenzie
16. Gary	Tolleston H. S., Biology, (1952)	Edith Wallace

Town	*School and Club*	*Sponsor*
17. Gary	Tolleston H. S., Future Scientists of America, (1949)	Arthur Kline
18. Gary	Wirt H. S., Biology (1945)	Mrs. Frances Huddleston
19. Gas City	Mississinewa Joint H. S., Science, (1936)	Roy McKee
20. Griffith	H. S., Science, (1953)	George M. Bunce
21. Hammond	Morton School, Science, (1949)	Nancy Lou Ritter
22. Hobart	H. S., Science, (1952)	Lola Stewart
23. Huntingburg	H. S., Science, (1949)	Wilmer K. Pellett
24. Indianapolis	Shortridge H. S., Naturalist's Club, (1947)	Max Forsyth
25. Indianapolis	Shortridge H. S., Science, (1931)	Mrs. Henrietta Parker
26. Indianapolis	Technical H. S., Nature, (1932)	Howard L. Cook
27. Indianapolis	Howe H. S., Science, (1949)	Jerry Motley
28. Indianapolis	Washington H. S., Science, (1931)	Estil Van Dorn
29. Lebanon	H. S., Jr. Explorers of Science, (1953)	Helen E. Reed
30. Lowell	H. S., Science, (1935)	Robert J. Brannock
31. Marion	H. S., Science, (1936)	Keith Stroup
32. Marion	Martin Boots Jr. H. S., Biology, (1953)	John Clevenger
33. Mishawaka	H. S., Science, (1936)	Darl F. Wood
34. New Albany	H. S., Science, (1935)	L. S. Rose
35. New Castle	H. S., Science, (1947)	Mary Rankin
36. Richmond	H. S., Science, (1950)	Kathryn Coulter
37. South Bend	Central H. S., Junior Izaak Walton, (1949)	A. L. Smith
38. South Bend	John Adams H. S., Adams Walton, (1953)	Ernest Litweiler
39. Sullivan	H. S., Camera, (1939)	Ruth Hinkle
40. Terre Haute	State H. S., Senior Science, (1939)	Russell McDougal
41. Valparaiso	H. S., Science, (1931)	Gerald Doeden

NECROLOGY

Will E. Edington, DePauw University

Clarence Everett Baker

Champaign, Illinois
November 1, 1896

Lafayette, Indiana
June 2, 1953

Horticulture has played an important part in the agricultural history of Indiana. The first Indiana Horticultural Society was founded in 1842, perished after a few years, and was succeeded, in 1860, by the Indiana Pomological Society which four years later became the second Indiana Horticultural Society. Following the founding of Purdue one of the very first appointments was that of John Hussey who served as Professor of Botany and Horticulture in 1874-75. In 1884 James Troop, Professor of Horticulture from 1884 to 1912, was one of the two teachers of agriculture on the Purdue staff. In the early days horticulture was chiefly concerned with the propagation, improvement and diseases of fruits and vegetables, but modern life is now also concerned with their preservation, storage and transportation. Among the leaders in research on this latter problem was Clarence Everett Baker who devoted almost a third of a century to horticultural research at Purdue.

Clarence Everett Baker was born at Champaign, Illinois, on November 1, 1896, received his early education there, and came to Purdue in 1920, immediately after receiving his B.S. degree at the University of Illinois, as an Assistant in Horticulture in the Experiment Station, and at the time of his death on June 2, 1953, he was an Associate in Horticulture with the rank of Associate Professor, in the Agricultural Experiment Station. While carrying on his research he earned the M.S. degree in 1929 and the Ph.D. in 1936, both at Purdue.

Dr. Baker's research, published mostly in Agricultural Station Bulletins, was concerned with pomology, pruning of orchards and management of orchard soils, cold storage and keeping qualities of fruit, and types of farm storage for fruits and vegetables. He also had received nation-wide recognition for his study on the storage and keeping qualities of coffee. He also did some teaching on the storage of agricultural crops.

He was a member of the American Society for Horticultural Science, the Indiana Horticultural Society and Sigma Xi, and for the past four years he had been on the scientific advisory council of the Refrigeration Research Foundation, one of whose meetings he attended just a month before his death. He joined the Indiana Academy of Science in 1949.

Dr. Baker was an excellent citizen who was active in civic projects and church work, having served on the board of stewards of the Methodist church for many years. The fruit growers of our state and nation owe him much for his outstanding service in research.

GEORGE W. BENTON

Albion, New York
November 15, 1862

Appleton, Wisconsin
June 23, 1952

At the time of the Fiftieth Annual Meeting of the Academy in November, 1934, fifteen of the Charter Members of the Academy were still living and ten of these Charter Members were present as honored guests of the Academy. Among these was George W. Benton, then a resident of New York City. His death on June 23, 1952, in his ninetieth year, leaves the Academy with Henry A. Huston as the last surviving Charter Member.

George W. Benton was born on November 15, 1862, in Albion, N. Y., and at the age of fifteen he entered the preparatory department of Wabash College where he continued until he received his degree in 1884. Immediately following his graduation he returned to Albion to become principal of the high school for the next two years, after which he went to Joplin, Missouri, to be office manager of a lead mine. Because of ill health he had to leave Joplin and he accepted a position as teacher of chemistry in Shortridge High School, in Indianapolis, and in time was appointed principal. In 1911 he accepted a position with the American Book Company, in New York, as assistant editor in chief, and in less than a year later he was made editor in chief and a director of the company. He continued in this capacity until 1934 and then, being past seventy, he retired from this heavy responsibility and became secretary to the board of directors, and he also continued to read manuscripts. After ten years of this he definitely retired and went to Appleton, Wisconsin, to live in the home of one of his two daughters, where he quietly passed away in his sleep on June 23, 1952.

While a resident of Indiana he was very active in the affairs of the public schools of the state and in the Indiana Academy of Science. At the Twenty-fifth Anniversary Meeting of the Academy in 1909, as retiring president of the Indiana State Teachers Association, Mr. Benton at the Academy Banquet extended the greetings of the Association to the Academy in the course of which he said, "We see in the Academy the most powerful agency in the solution of the great problem of fitting the highest development of scientific thought into the general scheme of education for all the people."

Mr. Benton was made a Fellow of the Academy in 1896. He was Press Secretary for five years, 1898 to 1902, Editor of the Proceedings, 1899-1901, and Secretary in 1910. During his term as Editor appeared "An Index of Proceedings, 1891-1900," some twenty-one pages of fine type. He was very active in making the Twenty-fifth Anniversary Meeting a success.

He presented a number of papers on chemistry before the Academy of which three were published in the Proceedings. He was much concerned about pure milk and clean water and, in 1895, having discovered bad samples of milk, he pointed out the necessity for chemical inspection of milk to guard against watering, skimming, and the introduction of adulterants such as vegetable and cotton seed oil mixtures.

George W. Benton was possessed of a most charming personality. He was a deeply read man and as a hobby he visited every well known battle-

field connected with the Revolutionary and Civil Wars and he learned all he could about the generals and their battle plans. He lived a long, interesting and worth-while life.

PHILIP WALTER BERG

Miles City, Montana — Lafayette, Indiana
October 13, 1918 — April 14, 1953

Philip Walter Berg, at the time of his death on April 14, 1953, was in the midst of the completion of the requirements for the Ph.D. degree in entomology at Purdue. He had shown considerable promise as a researcher and had completed and published several articles, two appearing in recent volumes of the Proceedings. His death at the early age of thirty-four is sincerely to be regretted.

He was born in Miles City, Montana, on October 13, 1918, but his public school work was completed in Marietta, Ohio, High School, following which he entered Marietta College where he received the B.A. degree in 1940. He was a graduate assistant at the University of Iowa from 1940 to 1942, and he later did some graduate work at Ohio State University and the Wood's Hole Biological Laboratory before coming to Purdue in 1946 as a graduate assistant in entomology. From 1943 to 1945 he was an Army technical sergeant in the malarial service.

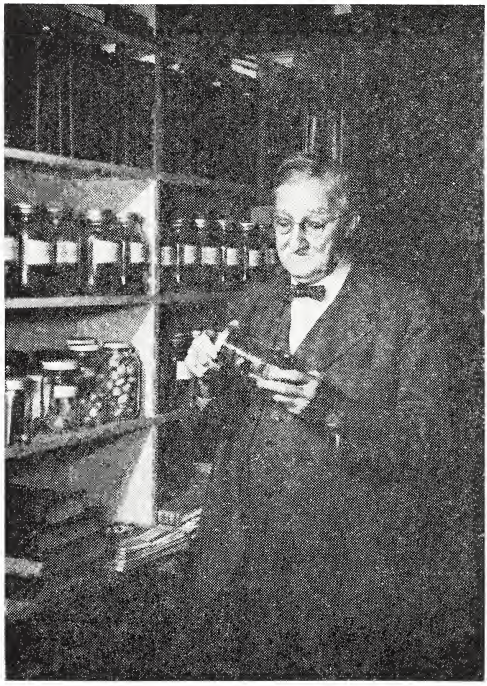
At Purdue he served for a time as a counselor in Cary Hall, a men's dormitory. He received the M.S. degree at Purdue in 1948 following which he was promoted to an instructorship in the Department of Entomology, and at the time of his death he had established a reputation as a conscientious, loyal worker and an excellent teacher.

He was a member of Phi Beta Kappa, Sigma Xi, Gamma Alpha, and Delta Upsilon, social fraternity. His genuine interest in a scientific career was shown by his membership in the American Association for the Advancement of Science and the Entomological Society of America, and his activity in the Indiana Academy of Science which he joined in 1946 immediately after he came to Purdue. His principal research work had been done in the study of the toxicity of certain insecticides.

CHARLES CLEMON DEAM

Bluffton, Indiana — Bluffton, Indiana
August 30, 1865 — May 29, 1953

Without doubt the plant life of no state in the United States is so completely known and catalogued as that for Indiana. This knowledge, of course, has been accumulated through the efforts of many botanists, professional and amateur, over the past century, but the final checking of known individual species and the addition of many new ones, revision of nomenclature, classification in a systematic way, and compilation of comprehensive text references, has been primarily due to Charles Clemon Deam, a non-professional botanist, who took up botany as a hobby in 1893 and pursued its study intensively for almost sixty years.



Charles Clemon Deam was a rugged individualist who appeared brusque and gruff to those not well acquainted with him, but to those who were closest to him and knew his intellectual integrity and scientific sincerity this outward brusqueness masked a humble, modest, unassuming man who despised sham and pretense and was deadly serious about his scientific work. Born on a farm in Wells County, near Bluffton, on August 30, 1865, he learned on the farm what hard work from sunrise to sundown was and he never got over the habit. He remarked once to his long-time friend, Mel T. Cook, that he believed he had split more rails than Abraham Lincoln and at the age of twenty-three he had helped build a rail fence 120 rods long. He finished high school, did a little teaching, and then entered DePauw in 1885 but at the end of two years, on account of finances, sold his books and walked home. That completed his formal schooling and a few years later, in May, 1891, he went into the drug business in Bluffton. However, the confinement in the store affected his health and two years later, following the doctor's advice, he began taking long walks into the country. He had not studied botany in high school or college but his study of the herbs and drugs in his store led him to hunt medicinal plants in his walks along roads and in fields and timber lots. Soon his avocation become almost a vocation with him and in 1900 a friend, J. R. Spivey, became a partner with him in the drug store and this gave him greater freedom for botanizing. But by 1899 he had gone far enough with his

studies to enable him to publish a paper in the Proceedings for that year on "The List of Plants Collected at Cedar, Shriner and Round Lakes."

He began making collections, purchasing books, subscribing for scientific journals, and corresponding with botanists. In time he bought a Model T Ford truck and equipped it for botanizing, and once traveled and lived in it for weeks, doing his own laundry and cooking his own meals. He visited every one of Indiana's 1,016 townships one or more times, and finally collected over 78,000 specimens and built up a library of approximately 3,500 bound volumes besides numerous pamphlets and reprints. In 1943 he sold the Deam Herbarium of 63,000 specimens and his library to Indiana University, but he kept some 15,000 specimens, as he said, for "tradin' stock." "The herbarium and the library together constitute by far the best record available of the vegetation of Indiana during the critical period marked by the disappearance of the original forests and the new biological adjustments accompanying the agricultural and industrial development."

Although author of numerous published listings and descriptions of plants, his life's work finally appears in four books: "Trees of Indiana," Grasses of Indiana," "Flowering Plants and Ferns of Indiana," and "Flora of Indiana," the latter a work of 1,236 pages and 2,247 maps, published in 1940. This latter work will serve as a model for future works on state floras and provides a background for arranging genera in a herbarium in a systematic way and includes a large proportion of the species of eastern United States. Since 1940, "Flora of Indiana" has been kept up to date through the efforts of an Academy committee in which Drs. Ray Friesner, T. G. Yuncker, Ralph Kriebel, and others, cooperated with Dr. Deam. The volume itself was the culmination of a series of twenty reports by Dr. Deam on "Plants New or Rare in Indiana," which appeared annually in the Proceedings, the last appearing in 1934.

By 1909 Deam's reputation was such that Governor Marshall appointed him as the first state forester, for the term 1909-1913. He was acting state forester, 1917-1919; state forester, 1919-1928; and research forester from 1928 to 1940. During all this time he retained his interest in his drug store although through the years he had different partners, and he held patents on a liquid meat smoker, a fly poison, and a quick freezing ice cream. Mrs. Deam helped him much in his work, reading and clipping botanical items, and helping otherwise. In 1904 he and Mrs. Deam spent three months in Guatemala and Mexico studying plant life and vegetation, and on another trip to the tropics he discovered 50 plants new to science. He had also made trips all over the United States. At his home in Bluffton he had a two-acre arboretum containing 500 varieties of trees and shrubs all properly labeled. Near Bluffton, nearly fifty years ago, he discovered a rare oak, now known as Deam's Oak, a hybrid between the bur oak and the chinquapin oak, and to preserve it he bought the ground on which it stands and gave it to the state.

He was the recipient of many honors. He received an honorary A.M. from Wabash College in 1920, and the Sc.D. degree from DePauw in 1932. In 1939 Indiana University conferred the LL.D. degree on him. He received the Pugsley Silver Medal in 1940 from the American Scenic and

Historical Preservation Society, and in 1947 he received the second Mary Sope Pope Medal of the Cranbrook Institute of Science. In March, 1952, he was made an honorary life member of the Bluffton Lions Club at a dinner attended by Indiana Conservation Department officials and representatives from Purdue and Butler Universities at which a portrait of Dr. Deam was unveiled, to be hung in the courthouse at Bluffton.

Dr. Deam was a member of the American Association for the Advancement of Science for 40 years and a Fellow, and he held memberships in the Botanical Society, the American and British Ecological Societies, and the Society of American Foresters. He joined the Indiana Academy of Science in 1900, became a Fellow in 1910, was Editor of the Proceedings for 1913, and was President in 1924. In 1951 he was made an Honorary Member of the Academy. He had served on various Academy committees at one time or another and was active in all its work until ill health interfered.

On April 23, 1953, Mrs. Deam, his companion and helper for 57 years, passed away, and five weeks later Charles Clemon Deam joined the "Giants of Other Days."

RAY CLARENCE FRIESNER

Bremen, Ohio
February 8, 1894

Indianapolis, Indiana
December 1, 1952

The death of Ray C. Friesner on December 1, 1952, came as a distinct shock to those who had met with him October 16 to 18 at the Academy

Meeting held at Valparaiso University, where he had reported completion and publication of the Ten-Year Index of the Proceedings. He had also presented a paper before the History of Science Section, and made the thirteenth report on "Indiana Plant Distribution Records" to the Plant Taxonomy Division. However, his teaching colleagues knew that he had not been well for several years. He was stricken on November 20 and passed away ten days later.

He was born on February 8, 1894, in Bremen, Ohio, of humble parentage. His mother died when he was six years old, but his father saw him through the Bremen public schools and he entered Ohio Wesleyan University where he received the A.B. degree in 1916. He immediately enrolled in the University of Michigan as a graduate assistant, was promoted to research assistant the next year, and by working the year round, received the Ph.D. degree in 1919. He accepted a position as Assistant Professor of Botany at Butler University that Fall in the Department of Biology under Dr. Henry Lane Bruner. The next year the Department was divided, Dr. Friesner taking over the botany and Dr. Bruner retaining the zoology. He was made an Associate Professor in 1922 and a full Professor in 1925. He became Director of the Division of Graduate Studies in 1944 and three years later was appointed Dean of the College of Liberal Arts and Sciences, but during these periods he continued as Head of the Department of Botany. Thus his whole professional life was devoted to Butler University which he served for a third of a century.

When he first went to Butler but three courses in botany were offered, but under his guidance the Department grew to a staff of four offering about thirty courses. He was deeply interested in research particularly of Indiana plant life and he worked very closely with Charles Deam. His special interests were in taxonomy of Indiana plants, the goldenrods of North America, and dendrology. In 1928 the Butler Botanical Garden was founded and in 1929 the Department began the publication of the "Butler University Botanical Studies" to encourage publication of research by staff members, advanced undergraduates and candidates for Master's degrees.

Dr. Friesner was author or joint author of over forty research papers most of which were published in the "Butler University Botanical Studies." In a number of these papers he collaborated with Dr. Stanley A. Cain and Dr. John E. Potzger. Since 1940 he had served as secretary of the Academy's State Flora Committee and he reported annually on "Indiana Plant Distribution Records," which reports were published in the Proceedings. Following the death of Dr. George Hume Smith who had been employed to compile the Index of the first fifty volumes of the Proceedings, Dr. Friesner took over and saw the Fifty-Year Index to completion in 1948. He then compiled the Index for volumes 51 to 60, which appeared in 1952. When he came to Butler the University had no herbarium, but at his death the Butler Herbarium had nearly 100,000 sheets of ferns and higher plants, several thousand algae, and over a thousand packets of mosses. He was an excellent teacher and an outstanding field man who inspired many of his majors to continue their studies to the doctorate. For departmental use he had written a Key to Indiana Plants.

Dr. Friesner was the recipient of a number of special honors. On September 16, 1944, he was the honored guest at a dinner sponsored by Butler alumni botany majors to celebrate the completion of the twenty-fifth year of the Department of Botany. At the Butler Commencement on June 7, 1948, he became the first recipient of the John Irving Holcomb award of $500 as the one who had done most for Butler during the year, and in making the award President Ross, of Butler, said, "His accomplishment as teacher, contributor to science and head of a department have been truly remarkable." At the 1947 Fall Meeting of the Academy he received the John M. Coulter Academy Award for his work as secretary of the State Flora Committee and for his researches on tree growth. Finally, his Alma Mater, Ohio Wesleyan University, conferred the honorary Sc.D. degree on him in 1951.

He was listed in *Who's Who in America*, *American Men of Science*, and *Who Knows and What*. He was a Fellow of the American Association for the Advancement of Science and the Ohio Academy of Science, and he was a member of Phi Beta Kappa, Sigma Xi, Phi Kappa Phi and Phi Sigma. He also held membership in the Botanical Society of America, American Genetics Association, Eugenics Research Association, American Association of University Professors, and the Illinois Academy of Science. He joined the Indiana Academy of Science in 1919, became a Fellow in 1925, was Secretary for the ten years from 1926 to 1935, and was President of the Academy in 1936. He served on numerous Academy committees and was unusually well versed on Academy procedure and he was ever ready to serve the Academy in every way possible.

In addition to his numerous duties as dean, department head, teacher and researcher, Ray Friesner found time to be active in the Indianapolis Downey Avenue Christian Church where, at the time of his death, he was chairman of the official Board of Directors, and where for the past twenty years he was teacher of the Philathea Class. He was particularly a student of St. Paul and he had made an extensive study with copious notes on this early Christian.

Ray Friesner was an indefatigable and efficient worker, a fine, inspiring teacher, an able and effective administrator, and a wise and sympathetic counselor of youth. He was an excellent research man and at his best in the field. For many years at the Spring Meetings of the Academy he conducted botany hikes. His untimely passing is a genuine loss to Butler University and to the State of Indiana, and to his numerous friends in the Academy and his church.

LLEWELLYN V. LUDY

Mill Grove, Indiana — Lafayette, Indiana
January 26, 1875 — November 8, 1952

It is not given to many men to be associated actively with an institution for fifty years, but Llewellyn V. Ludy's whole life from boyhood on was influenced by Purdue and he is a part of the tradition of Purdue, for he entered that University for his college preparatory work and continued

until he received the bachelor's degree in Mechanical Engineering in 1898. As a Freshman he took the lead in organizing the band which has since become famous as the Purdue Military Band, and he was a musician and an officer of that band for four years. In 1900 he received the professional degree of Mechanical Engineer.

He began his career as a staff member at Purdue, in 1898, as an assistant in the engineering laboratory, became an instructor in mechanical engineering the next year and Professor of Mechanical Engineering in 1901. Except for the year 1911-1912, which he spent at the University of Wisconsin as Professor of Steam and Gas Engineering, his whole professional life was spent at Purdue, until his retirement in 1945. Following his retirement he continued to be active as a consulting engineer.

Professor Ludy was born on January 26, 1875, at Mill Grove, Indiana. He early showed qualities of leadership and he had the scholarship to sustain that leadership. He was the ranking student in his graduating class at Purdue and in his Senior year was designated the Wilbur Scholar of Tau Beta Pi, general engineering honorary scholarship fraternity. Following his graduation he spent the summer of 1900 in Washington, D. C., as an expert in the Bureau of Forestry, and the summer of 1901 as an inspector for the Carnegie Steel Corporation. During World War I, in 1918, he was in charge of the special training of soldiers at Purdue, and during World War II he was local representative of the U. S. Shipping Board, Emergency Fleet Corporation.

He was the author of six books on engineering: Air Brakes, 1915; Locomotive Boilers, 1916; Steam Engines, 1916; Steam Engine Indicators, 1916; Valve Gears, 1916; Mechanical Engineering Laboratory Notes, 1942. His research interests were in steam and gas engineering.

Professor Ludy was a Fellow of the American Association for the Advancement of Science and a member of the Society of Mechanical Engineers, the Society of Engineering Education, and the Indiana Engineering Council. He was also a member of Sigma Xi, Tau Beta Pi and Pi Tau Sigma, and the social fraternity Sigma Phi Epsilon, being a Faculty sponsor. He was also listed in *Who's Who in America*. He joined the Indiana Academy of Science in 1918 and was later made a Fellow, but since the Academy has no section in engineering he was not active in Academy work.

He was interested in civic affairs and was a long time member of Rotary and the Masons. An active Presbyterian, he was an elder and served on committees of the Presbytery and Synod, and for more than twenty-five years he was secretary of the Board of Westminster Foundation and influential in organizing and building the University Presbyterian Church.

Professor Ludy was a sincere, friendly man who tried to see the good in his fellowmen. Quiet and reserved, and possessing a calm and even disposition, he was a wise counselor of youth and a teacher who trained men by example. Excellent citizen and sincere churchman, he lived a long and useful life. He passed away in Lafayette, Indiana, on November 8, 1952.

JASPER PAUL SCOTT

Whiteland, Indiana — Indianapolis, Indiana
December 9, 1897 — September 8, 1953

The Academy derives much of its value and strength from the scientists in industry whose research is in no sense academic but generally devoted to immediate practical ends. Jasper Paul Scott, who passed away at the untimely age of fifty-five, on September 8, 1953, was the fourth scientist from Eli Lilly and Company lost to the Academy during the past three years.

Mr. Scott was born near Whiteland, in Johnson County, on December 9, 1897, and, following the usual public school education, entered Franklin College where he graduated magna cum laude in 1919. He taught science in Bedford High School the next year and in 1920 became a research chemist with Eli Lilly and Company. During the next thirty-three years he was successively assistant director of research development, director of research contacts, director of functional co-ordination, and director of industrial engineering, before being named, on December 1, 1952, executive director of operations planning. In 1939 Franklin College conferred on him the honorary Sc.D. degree for his work in biochemistry.

In his research work he made contributions to the development of insulin, liver and pituitary extracts, and vitamin products.

Dr. Scott was a member of the American Association for the Advancement of Science, the American Chemical Society, and the American Pharmaceutical Association. He joined the Indiana Academy of Science in 1946 but he had not been active in its work. A thirty-second degree Mason, he was affiliated with the Mystic Masonic Lodge and the Scottish Rite in Indianapolis. He was also a member of the Baptist Church.

A good citizen, an excellent scientist, and a fine man, popular and well liked as a member of the scientific staff at Eli Lilly and Company, he made his contribution to the welfare of humanity and his work will long benefit mankind.

KARLIS STARCS

Lubeja, Latvia — Indianapolis, Indiana
May 18, 1897 — February 4, 1953

War, the result of man's folly and his greatest enemy, is no respecter of persons in an invaded land. The Baltic countries in Europe, victims of the worst in two World Wars, have suffered the loss of their wealth and their intellectual leaders. Many of these trained and skilled workers have fled their native lands and the United States has been fortunate to serve as a haven for many of them. American universities, particularly the larger ones, have gladly employed many of these refugees on their staffs, and have thus availed themselves of their genius and talents. Other escapees have not been quite so fortunate on account of language or other difficulties for which they are not responsible. Karlis Starcs was such a person.

Karlis Starcs, together with his wife and two sons, came to the United States in 1950 with the help of the International Refugee Organization, and arrived in Indianapolis on December 23, and accepted a position in January, 1951, as assistant gardener at the home of Mr. Eli Lilly. A native of Latvia, he was born on May 18, 1897. Completing his high school work in 1918, he was employed as a botanist and began his study of the Natural Sciences at the Latvian University. For the next twenty-five years he was employed as a botanist, but he completed the work for the Master's degree in 1936, and from 1937 to 1944 he was assistant director of the Latvian Institute of Plant Disease in Riga. In 1944 he was evacuated to Germany and from February to June, 1945, he was Deputy Conservator and Botanist at the Herbarium Haussknecht in Weimar, Bavaria, and then he was evacuated again, this time to the United States Zone in Bavaria. During 1946 and 1947 he was Senior Assistant and Lecturer in Dendrology and Phytopathology in the UNNRA University in Munich in the Agriculture and Forestry Department. Also from 1944 to 1950 he explored Bavarian flora and made a large plant collection as a private botanist-collector having a Displaced Persons Status. When he left Latvia he left behind his private botanical collection of about 100,000 specimens. When he entered the United States he brought with him over 6,000 specimens of fungi, mosses, flowering plants, and lichens.

Mr. Starcs was a fine looking man, an excellent botanist, and a cultured man who wrote and spoke fluently Latvian, German and Russian, and could read understandingly professional literature in English, French, Latin, Scandinavian and Slavic languages. He was affiliated with a number of European botanical societies and he had published sixty-six articles totaling about 1,700 pages. He had a total of 32 years of experience in plant collecting and herbarium work. He joined both the Botanical Society of America and the Indiana Academy of Science in 1952, but his premature death on February 4, 1953, prevented his participation in their activities.

His wife, Mrs. Helene Starcs, is also a trained botanist and was a teacher of Natural Sciences at the University of Riga, and since the passing of Mr. Starcs, she has joined the staff of the Department of Botany at Butler University as a Research Assistant in Botany.

PHILIP FREELAND TRYON

Chicago, Illinois — Terre Haute, Indiana
October 4, 1914 — February 19, 1953

In the death of Philip Freeland Tryon on February 19, 1953, at the age of thirty-eight, the Academy lost one of its most promising and productive younger members, for he was not only the author or joint author of seven research papers in chemistry, but he also held some 17 patents on chemical processes and chemical compounds, and he had three patents pending at the time of his death.

He was born on October 4, 1914, in Chicago, Illinois, received his public school education there, and entered the University of Chicago where he received the B.S. degree in 1934. He secured the M.S. degree at Cornell University in 1937, and then returned to the University of

Chicago where the Ph.D. degree in organic chemistry was conferred on him in 1939. He immediately entered the employ of the Chemical Solvents Corporation, at Terre Haute, Indiana, as a research chemist. He spent six years in research development and production of antibiotics, and seven years on industrial chemicals.

During these years of research he worked specifically with the chemistry of nitroparaffins, isolation of streptomycin and bacitracin, chemistry of hydroxylamine and the production of hydroxyl-ammonium salts, synthetic organic insecticides, plasticizers for synthetic rubber, and hydrogen-deuterium exchange reactions of phenols and phenol ethers.

Dr. Tryon was a member of the American Chemical Society, and of Phi Beta Kappa and Sigma Xi. He joined the Academy in 1946 but he had not been active in any Academy work. He was also a member of the Alpha Tau Omega social fraternity.

He was a member of the Congregational Church in Terre Haute, and he was active in Cub Scout work with his two sons. His principal hobby was botany and he was much interested in the conservation of our natural resources.

In the passing of Philip F. Tryon while just entering the prime of life and approaching the heights of a research career, the Academy, the State, and industry have suffered a real loss.

PRESIDENTIAL ADDRESS

Some Recent Advances in Experimental Chemotherapy

H. M. Powell, Lilly Research Laboratories, Indianapolis

In 1928 the writer contributed a chapter on "Precipitins and their Applications" to a book entitled The Newer Knowledge of Bacteriology and Immunology, edited by Jordan and Falk of the University of Chicago. This chapter was concerned with what is now an almost forgotten area in the one-time classical field of immunology, a subject founded by the great works of Ehrlich, Bordet and others. The last chapter in this volume of 1928 happens to be a long one on "Chemotherapy of bacterial diseases" by John A. Kolmer. Perusal of this last chapter by anyone interested will reveal that about all we had at that time in the way of disease-curing agents comprised (a) quinine for malaria, and (b) arsenicals, etc., for syphilis, and practically nothing for bacterial diseases. This situation continued for another eight or ten years following 1928, then came the sulfonamides. We are citing these old items not on account of their importance but as a background of old works rendered obsolete by new knowledge.

The present status of successful everyday chemotherapy of many of the severe infectious diseases of human beings, including use of the sulfonamides and antibiotics, attests a tremendous change which has come about in a very few years. This has been a spectacular period indeed in the conquest of human disease. There has been nothing quite like it in the previous history of human infectious disease.

However in spite of this it may be well to take a conservative look at what has come about in practical and useful chemotherapy. First, it is noticed that the wonder drugs lose a little luster as time goes on. Sometimes microorganisms get used to these drugs and on rare occasions a few bacteria have become so acclimated to a wonder drug that they need the new drug as part of their diet. This is disconcerting to say the least. Sometimes the wonder drugs cause some undesirable side reactions.

The particular area of chemotherapy upon which we wish to focus attention in this report however is not the above limitations but a segment of infectious disease against which no drug as yet has had any effect. This includes the infections caused by the so-called small viruses. This implies that some of the large viruses have been overcome by chemotherapy and this is indeed true. Other diseases, possibly of infectious nature, which have not at all been overcome by new drugs are the tumors, however we shall not be concerned here with the tremendous subject of tumor study.

The small viruses, including some types of encephalitis, poliomyelitis, and also influenza and others, comprise a hard subject to deal with. Sometimes the infected host becomes so riddled with virus, even in a matter of hours, that what ordinarily would be a good drug with leisure action would have no chance in such rapidly progressing infections. We have

been nevertheless attracted to this study mainly on account of the virgin nature of the field and the recent availability in our laboratories of large numbers of possible antibiotics made from fungi collected from soil samples from many areas over the world. A good many thousands of these materials have been subjected to so-called antiviral screening tests in which they are tried out, mainly in infected white mice in the laboratory. Out of this great number has come several antibiotics, one of which is of experimental interest in this field and some facts about this one may be presented.

In August, 1952, we published a short report on this subject in the journal, Antibiotics and Chemotherapy (1). In this report a Penicillium mold extract or filtrate designated serially as 8450 was shown to have preventive action in mice against 100 to 1,000 fatal doses of either MM or Semliki Forest virus and curative action against ten fatal doses or less of virus. These viruses are truly small viruses. Best prevention was exhibited by mice to which antibiotic 8450 had been given about twenty-four hours before infection with virus. Cures were obtained in a small way for a short time post-infection. These results appeared of interest since antibiotic and virus could be given by different routes of injection with successful results, and the action appeared to be truly in vivo, although the 8450 apparently did not act directly on the virus. Previously we had observed no similar success with many previous mold filtrates, drugs, etc. and previous publications appeared discouraging.

In the report of last year we mentioned that although multiple dose treatment of mice with 8450 was first used and found effective, the duration of treatment might be shortened to a single dose of filtrate. This single dose of filtrate was found to have a considerable carry-over effect in terms of prevention, and its effect could be observed for as long as three days. Moreover, mice which were treated with a series of doses of antibiotic 8450, then given a rest, were found again to be protectable by a new dose of 8450. Also, we noted practically no active immunity in mice once protected from MM virus with 8450 and then rechallenged with the same virus after a period of resting. We obtained no prophylactic results against influenza A and B virus, fixed rabies virus, poliomyelitis virus when given intracerebrally, meningopneumonitis virus, lymphocytic choriomeningitis virus, lymphogranuloma virus, and typhus rickettsiae.

Attention in the first report was also called to two particular limitations, namely in antiviral tests in mice infected with MM or Semliki Forest virus, although we observed successful results from several combinations of different routes of injection of antibiotic 8450 and virus, we got practically no positive results in tests in which (A) 8450 was given orally, or (B) virus was given intracerebrally. The 8450 on the one hand was either destroyed or not absorbed from the gastrointestinal tract, and on the other hand intracerebrally injected virus proved too much for the agent to overcome. These particular limitations may or may not be related to the fact that antibiotic 8450 is still in a crude form and activity is confined to a substance of large particle size incapable of dialysis and possibly incapable in the crude form of rapid transport extravascularly through the tissues.

In presenting further observations on the action of 8450 against viruses we shall utilize tests against MM virus in mice and shall not refer to Semliki Forest virus infection since the activity of 8450 against these two viruses is very similar. Also, we would like to present some results of the action of 8450 in mice infected peripherally with type 2 poliomyelitis virus.

It may be mentioned at this point that work on purification of 8450 is not sufficiently advanced to merit a report at this writing. The mold which produces the agent called 8450 is identified as *Penicillium stolonif-erum,* and the preparation which we have used for the most part has been a dried filtrate with very little purification. This is rehydrated before use to original volume.

The maximum extent of effective chemoprophylaxis of 8450 against MM virus mice which we have attained is indicated as follows: Different groups of ten mice were treated chemoprophylactically by the intraperi-toneal route with a constant dose of 0.5 ml of 8450, and twenty-four hours later these mice along with controls were challenged with different decimal dilutions of MM virus administered subcutaneously. Protection against more than 1000 MLD of virus is obtained in this way.

An alternative method of assaying the titer of 8450 is illustrated as follows: In this experiment a constant dose of challenge MM virus is used, namely 10^{-6} ml amounting to about 100 LD_{50}, and diminishing doses of 8450 employed. It may be observed that dilutions of 8450 of 1:8 to 1:16 appear to span a 50 percent effective chemoprophylactic dose, and the untreated virulence control mice indicate an LD_{50} of test virus of about 10^{-8} ml. This scheme of testing is about as satisfactory as we have used for comparing titers of different batches of 8450. Since 8450 appears to have no antibacterial or antiphage spectrum, the titer of any given batch has to await the outcome of a ten day mouse test employing MM virus as just described.

Although we have administered 8450 mainly by the intraperitoneal route and MM virus mainly by the subcutaneous route, other combinations of routes of injections are of interest. Antibiotic 8450 may be injected chemoprophylactically by the intraperitoneal route, and MM virus in decimal dilutions may be given by either of two alternate routes, namely intranasally and intramuscularly. Corresponding virulence control mice are used. A considerable measure of chemoprophylactic activity of 8450 is indicated against virus given in these ways, namely intranasally or intramuscularly, just as it may be shown that virus may be overcome when it is injected under the skin.

It is premature to present experimental results dealing with the nature of 8450. It may be repeated however that it appears in its present form to be of large particle size, and it does not dialyze. Moreover it is moderately thermolabile. Comparative tests of native 8450, along with material immersed in a small test tube in boiling water for fifteen minutes, and also material which had been autoclaved at fifteen pounds pressure for one hour indicates a trace of activity in the boiled sample, however the autoclaved sample has lost about all of its activity.

It appeared of interest at this point, since most experiments hereto-

fore had dealt with treatment given ahead of infection to give some results of post infection chemotherapy. Three groups of sixty mice were injected subcutaneously with MM virus in a dilution of 10^{-7}. One group was given 8450 intraperitoneally three hours and twenty-four hours afterwards and another group was given the agent at three hours after infection only. Corresponding control mice are used and these include an additional group of mice given a 10^{-8} dilution of virus. This experiment on completion shows a definite measure of chemotherapeutic effectiveness against a dose of virus which kills most but not all of the control mice. A single dose of 8450 given three hours after infection is as good as two doses given at three hours and twenty-four hours after infection.

Further assays of chemotherapeutic effectiveness have been done from time to time in which treatment follows infection by a longer time and results of such tests show that a moderate degree of chemotherapeutic effectiveness is obtained when 8450 is given four hours after virus, and this is also evident at six and eight hours after infection, although demonstrable activity decreases at these times.

In the first brief report on 8450 of a year ago, we stated that mice once protected by 8450 showed no substantial immunity to a rechallenge dose of MM virus. It appears that mice treated before infection show less subsequent active immunity than those treated after infection, also the size of the infecting dose of virus against which protection is obtained may be related to presence or absence of subsequent active immunity.

In the past few months we have gotten some positive results in tests of chemoprophylaxis with 8450 against type 2 poliomyelitis virus injected peripherally into mice. Previous unsuccessful results mentioned in the initial report of last year were based on experiments in which Lansing virus was given intracerebrally to mice. In a recent short report (2) on poliomyelitis mouse work we have used a special line of MEFl virus repeatedly passaged in very young hamsters. This virus has definite peripheral virulence for mice and intraperitoneal, intramuscular, or intravenous routes of injection of virus result in fatal infections. With successive passages of this MEFl strain of virus in seven day old hamsters, peripheral virulence has increased greatly. Mice of 12 grams in weight suffice best for these tests and it appears such experiments provide a basis for in vivo chemotherapy tests against type 2 poliomyelitis virus administered peripherally in small animals before resorting to monkeys. The combined results of several chemoprophylactic poliomyelitis tests of antibiotic 8450 in these mice show that the strongest effects, i.e. against about 10 MLD of virus, are produced by treatment of mice intraperitoneally with 8450 followed by MEFl virus injection intraperitoneally twenty-four hours later. If repeated intraperitoneal doses of 8450 are used, injection of 8450 is skipped on the day of intraperitoneal virus injection. Chemoprophylactic effects are also produced by injection of 8450 intravenously twenty-four hours ahead of intraperitoneal injection of virus. Other combinations of routes of treatment and virus injection show decreasing degrees of positive results. Oral treatment with 8450 did not appear effective chemoprophylactically, nor did intravenous injection of MEFl virus prove very susceptible of chemoprophylaxis.

Some poliomyelitis mouse experiments have been done in which mice once protected against MEFl virus infection by 8450 were kept for some time and were then rechallenged with virus along with new controls. Sometimes no active immunity appears to have been acquired. These results are similar to some of those obtained in mice once protected from MM virus by 8450 and then rechallenged subsequently. In both cases protection by 8450 against the first exposure to virus seems to ensue before the virus has had time to initiate an immunizing action. We have observed in mice suitably protected by 8450 that the animals soon rid themselves of the initial dose of virus. Lack of active immunity in mice once protected with 8450 is not always the case. In some instances mice once protected against MEFl virus appear after a longer rest to have acquired a little active immunity.

At this writing two of our associates, Hull and Lavelle, have reported the action of 8450 on all three types of poliomyelitis virus in tissue culture (3). Suitable pre-infection treatment of roller tube monkey testicular cultures renders these cells refractory to the usual cytopathogenic action of poliomyelitis virus.

Subsequent to our first report on this antibiotic in August, 1952, Shope in May of 1953 has published three papers (4) dealing with a *Penicillium funiculosum* agent which seems to be quite similar in activity to 8450.

Finally, more time is needed for more work on 8450 in several directions of considerable interest. Since theoretical considerations of mechanism of action do not help very much, we have refrained from an exposition of this matter.

SUMMARY

Additional results have been presented concerning extent of chemoprophylaxis obtained against MM virus infections in mice with a filtrate from *Penicillium stoloniferum* known as 8450. This action amounts to 2 or 3 logs of protection, and filtrate and virus are injected by different routes.

Chemotherapy up to about eight hours after MM virus infection is effective provided infecting dose of virus is near the 1 MLD level.

This filtrate, having a serial number of 8450, accomplishes chemoprophylaxis and chemotherapy in vivo when given to mice by routes of injection separate from virus injection.

A limited degree of chemoprophylaxis with 8450 has been obtained in mice infected peripherally with type 2 poliomyelitis virus.

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ANTHROPOLOGY

Chairman: PAUL GEBHARD, Indiana University

THOMAS B. NOBLE, M. D., Indianapolis, was elected chairman for 1954

ABSTRACTS

The C. L. Lewis Stone-Mound and Its Cultural Affiliation. JAMES H. KELLAR.—Stone mounds are one of the most widely distributed archaeological manifestations in the eastern United States, but the problems of excavation and the paucity of associated cultural materials have tended to inhibit investigation or publication of results. Although an Adena-Hopewellian relationship is suggested by previous work, a precise statement of affiliation is not possible. The structural and cultural concatenation of the C. L. Lewis stone-mound located near St. Paul, Shelby County, Indiana, is strongly reminiscent of Adena material and may assist in placing at least a portion of the stone-mound distribution within this cultural and chronological framework.

The Asiatic Relationships of the Deneid Variety of American Indian. GEORG K. NEUMANN, Indiana University.—A search through the Russian scientific literature for descriptions of archaeological and recent Siberian cranial series shed light on the nature of the relationships of a number of varieties of American Indians to Asiatic Mongoloids. In this paper the nearest relatives and possible ancestral groups to the Deneid variety are under consideration. On the basis of cranial morphology the Aleuts, the Haida, a number of Athabascan-speaking tribes of the interior of British Columbia, and the Apache of the Southwest are the most closely related. These groups can be considered as constituting the Deneid variety. A number of Central Asiatic tribes — Kalmucks, Telengetes, Tuvinians, Buriats, Mongols, some of the Tungus, and Gilyaks — make up another variety. This is von Eickstedt's Tungid race, here designated as the Evenkid variety, after the self-appelation of the Tungus. These two varieties, both historically recent, are related to each other in that they can be derived from a common ancestor, the Neolithic Baikal people of which the Lamuts are modern representatives.

Aleutian archaeology in relation to Asia and America. PAUL GEBHARD, Indiana University.—The prehistory of the Aleutian islands is seen to consist of four gradating cultural phases. The earliest seems to have been a core-and-blade tool industry derived from northeastern Asia where it is best known in the mesolithic of Mongolia and Manchuria. The second phase, "original eskimo," represents an arctic-adapted cultural complex which derived from western mesolithic cultures (eg. Maglemose, Kunda, Arctic) and from the upper palaeolithic and neolithic of Siberia. This "original eskimo" spread across Bering straits, and probably also directly by sea, to the Aleutians. After arriving in the New World this generalized

eskimoid culture became quite specialized, and in this more developed form entered the Aleutian islands from Alaska, constituting the third phase. Lastly, a minor fourth phase consists of influences received from western coastal Canada.

[Aleutian artifacts were exhibited.]

The political organization of the Three Fires. J. A. JONES, Indiana University.—Traditionally, the "Three Fires," the Ottawa, Chippewa and Potawatomi were one people who migrated west together from the Atlantic coast. The Potawatomi supposedly split off first, and went south, the Ottawa remained around the Straits of Mackinac (the point of dispersal), and the Chippewa continued west to settle around the shores of Lake Superior. Linguistic evidence suggests this may have happened, for Ottawa and Chippewa are very close dialectically, and Potawatomi is not too much different.

There is no evidence, however, in the early documentary sources, to support the thesis that at White contact times anything approaching political confederation between these three groups existed. It is doubtful even that any stable political unit larger than the local group had developed in this area in aboriginal times.

A taxonomic system based upon political organization suggests that the broad classifications of Ottawa, Chippewa, and Potawatomi are arbitrary, and probably originate as much in the minds of the classifiers as from the data.

The Place of the *Australopithecinae* Among Human Fossils

RAYMOND W. MURRAY, C.S.C., University of Notre Dame

Much of the speculation concerning the origin of man today centers about the Australopithecine fossils of South Africa. Most of the literature on human paleontology in recent years has dealt with these controversial fossils. They are commonly pictured as plains-living "apes" walking erect; their brain size exceeded that of adult gorillas. Some authorities say that they were already human; others classify them as apes; a third group regards them as "neither a human ancestor nor a mere deviant ape group, but a third line of evolutionary development, independent of the two others and intermediate to them because derived from the same ancestry farther back." [1]

The very name "Australopithecus" is misleading. It suggests Australia rather than Africa. We are apt to confuse it also with *Africanthropus njarasensis*, discovered by Kohl-Larsen in East Africa in 1935 and described by Weinert after World War II. The "Australian" idea was introduced into the South African fossil field by Dr. Robert Broom, originally a vertebrate paleontologist, who made his first excursion into the field of human paleontology in 1923 when he described a fossil which differed from those of Bushmen and Hottentots as a new (Koranna) type. Because of its prominent supraorbital ridges he thought it was related to the Australoid primitive type.[2] This reference prompted Dart, who "discovered" the first fossil of the type we are to consider here a year later, to call his more primitive fossil *Australopithecus africanus* ("African southern ape"). Since 1924 portions of about 25 individuals, consisting mostly of skull parts but also of pelvic and leg bones, have been found. In this paper we shall consider the chief discoveries in sequence, various evaluations which have been made of them, and finally some tentative conclusions concerning the place of the *Australopithecinae*.

I. The Discoveries

The first *Australopithecinae* discovery was made by a quarry worker in a "desert limestone" formation near Taungs, about 200 miles southwest of Johannesburg, in 1924. It was brought to Professor Raymond Dart of the University of Witwatersrand, Johannesburg, for identification.[3] The discovery proved to be the skull of an immature creature whose brain size was about 500 c.c. Dart estimated that as an adult it would have reached about 600 c.c., regarded as considerably below the lower human limit. He regarded it as a "manlike ape" representing a family intermediate between the higher apes and man but nearer the human ancestor than any fossil discovered elsewhere. When Dart's discovery was announced in England in 1925 it met scant enthusiasm. Although Sollas and Elliot Smith sup-

1. KROEBER, A. L., *Anthropology*, second edition, New York, 1948, p. 92.
2. *Yearbook of Physical Anthropology for 1948*, Volume 4, New York, pp. 42-43.
3. Several of the South African fossils were found by non-scientists; so, for that matter, were most of the important Java fossils.

ported Dart, most authorities regarded the skull as merely that of a young ape and referred to it as the Taungs Ape.

Dr. Broom of the Transvaal Museum, Pretoria, agreed with Dart and, undismayed by the criticism which Dart had received, set out to find the fossil of an adult member of this family. In 1936 he announced the discovery of such a skull, blasted out of solid "bone breccia" in another limestone quarry at Sterkfontein, about 20 miles northwest of Johannesburg. This Sterkfontein skull, that of a young adult with most of his teeth intact, also had a brain case of about 500 c.c. Broom first called it *Australopithecus transvaalensis* but later, following the finding of several other skulls and fragments of skeletons in the same area, assigned it to a new genus, *Plesianthropus transvaalensis.* He described this new genus as a "remarkably human type."

In 1938 Broom announced the discovery of a "somewhat different type of ape-man" with a "much larger brain" (650 c.c.) which had been made at Kromdraai, about two miles from Sterkfontein. This adult "third type" he classified as of still another genus and species, *Paranthropus robustus*, "robustus" because of its larger size.[4]

During World War II very little research was done in the South African caves, but in 1947 Dart announced the discovery of skull parts of what he believed to be an adult of the family previously found at Taungs. This fossil was found in the Makapan caves in the northern part of the Transvaal, about 200 miles from the site of the Taungs discovery. Its brain size was estimated to be 650 c.c. Dart believed that he had evidence that the creature used fire and so he called it *Australopithecus prometheus.* Jaw parts of another creature of the same type were found at the same site a year later.

Between 1948 and 1950 Broom and his assistant, J. T. Robinson, discovered skull parts of several more individuals of the *Paranthropus* type at Swartkrans, only a mile from the Sterkfontein cave. This discovery was placed in a new species, however, *Paranthropus crassidens*, "crassidens" because it was "coarse-toothed." Broom estimated the cranial capacity of this species to be over 900 c.c., thus falling well within the lower border of the human range (750 c.c.) set up by Keith in 1949. Finally, in 1949, shortly before Broom's death, Robinson found the lower jaw of what he regarded as still another type with an even larger brain at the Swartkrans site. Robinson classified this as a new genus, *Telanthropus capensis.*

II. Evaluations of the Discoveries

In attempting to evaluate the discoveries we shall consider first the estimates of the Dart-Brown-Robinson (the "South African") school and then those made by others.

Evaluations by the South African School. The claims made by the South African group are rather startling. Broom described the Australopithecines as "small-brained men" who "walked on their hind feet, and used their delicate hands for the manipulation of tools and weapons." "We

4. BROOM, ROBERT, "The Fossil Ape-Men of South Africa," *Proceedings of the Pan-African Congress of 1947 on Prehistory,* New York, 1952, pp. 107-111.

have reason to believe," he says, that "they must have hunted in packs, and it seems not improbable that they had some kind of speech." [5] Dart is not only convinced that they made use of fire[6] but he believed he saw evidence of the use of a double-pronged implement to fracture baboon skulls and of some sort of weapon for fracturing the skulls of fellow Australopithecines.[7] Robinson claims that *Telanthropus* had already crossed over from the Australopithecine group and was a true man.[8] Both Broom and Robinson believe that the geological age of the fossils goes back to the Pliocene and extends upward through the lower and middle Pleistocene.[9]

It is suggested now that the South African and East African fossils are closely related to the *Pithecanthropus* fossils of Java. Broom and Robinson saw affinities to *Pithecanthropus* in *Telanthropus*. Robinson now sees a resemblance between a "giant size" creature, *Meganthropus africanus*, discovered in East Africa in 1939, and the Javan *Meganthropus* found by von Koenigswald in 1941. He believes that both represent a once widely distributed Australopithecine group.[10] If we are to believe the Dart-Broom-Robinson school the whole jig-saw puzzle of early fossil man now falls into order. They not only believe that the Australopithecines constitute the most important discoveries in the history of human paleontology but also that a rather definite link has now been established between the *Simiidae* and mankind. As Broom said, "It looks as if we have already solved the problem of the origin of man." [11]

Evaluations by Others. Time may prove that Broom was right. But it must be admitted that Broom was an enthusiast. At this point then it will be well to try to carry out the advice given by Franz Weidenreich in one of the last papers he wrote: "the Australopithecinae problem has first to be freed from all emotional interpretation and brought back to a sound objectivity." [12] Let us see now what some of the authorities not too closely associated with the Australopithecine discoveries have to say about them. We shall present these opinions under the following headings: (1) Culture, (2) Head, (3) Posture, (4) Geological Age.

1. *Culture.* The claim that *Australopithecus* had a culture can be disposed of rather quickly. Although the Dart-Broom-Robinson school claims that the Australopithecines spoke, no one else seems to agree. The artifact claim is based upon some marks found on baboon skulls and upon the fractures in some of the Australopithecine skulls. Evidence of the use

5. BROOM, R., *Finding The Missing Link,* London, 1950, p. 79.

6. *Ibid.,* p. 74.

7. *Yearbook of Physical Anthropology for 1948,* New York, pp. 23-24.

8. *Yearbook of Physical Anthropology for 1950,* pp. 40-41.

9. BROOM, R., *Op. cit.,* p. 78; ROBINSON, J. T., "Meganthropus, Australopithecines, and Hominids," *American Journal of Physical Anthropology,* Volume 11 (March, 1953), p. 32.

10. ROBINSON, J. T., *Op. cit.,* pp. 1-38; *Yearbook of Physical Anthropology for 1950,* pp. 27, 41. (The African *Meganthropus,* a small jaw part, was also discovered by Kohl-Larsen and named by Weinert.)

11. *Op. cit.,* p. 77.

12. "About the Morphological Character of the Australopithecinae Skull" in *Robert Broom Commemorative Volume,* Alex. L. Du Toit, ed., Special Publication of the Royal Society of South Africa, Cape Town, 1948, p. 158.

of fire is attributed to microscopic and chemical study of a few specks of carbon black on some animal bones found with *prometheus*. Although George B. Barbour of the University of Cincinnati who studied the evidence is inclined to agree,[13] few if any others support the South African school on these points. Pierre Teilhard De Chardin, who also visited South Africa and studied the same evidence, found no proof of fire or the use of true implements.[14]

2. *The Head.* Much has been written about the brain and teeth of the Australopithecines. William K. Gregory, who visited South Africa in 1938 and thereafter became one of the first Americans to emphasize the human features of the Australopithecines, says they "combined brains of only ape-like bulk with teeth of human or near-human patterns" and that the form of the dental arch was "approaching the human stage."[15] Weidenreich (1948), Bronowski and Long (1951), and Le Gros Clark (1952) take a similar view regarding the teeth. S. Zuckerman, however, disagrees.[16] Most authorities agree with Gregory (against some of the claims of the South African school) that the brains were ape-like in bulk. Weidenreich also claimed that the shape of the head was distinctly ape-like, and Ernst Mayr says the small-sized brain and the "protruding face" are simian.[17]

But brain-size may not be a matter of prime importance in evaluating the status of man-like fossils, if we are to judge by the discussion of this point at the International Symposium on Anthropology in New York City in 1952. William L. Straus, Jr., observed: "Some of the recently discovered Australopithecines apparently had brains of a size that carried them across Keith's Rubicon, but we know nothing of their cerebral quality. We cannot admit them to human status on brain size alone."[18] Kenneth P. Oakley agreed that quality was the important thing, reminding his audience that Weidenreich had likened much of the interpretation of inter-

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13. "Ape Or Man?", *Yearbook of Physical Anthropology for 1949,* pp. 132-133 (Reprinted from *Ohio Journal of Science,* Vol. 49). He refers (p. 133) to a communication received from Dart reporting "evidence of a bone and horn culture" at Makapan.

14. "On the Zoological Position and the Evolutionary Significance of Australopithecines," *Transactions of The New York Academy of Sciences,* Ser. II, Vol. 14 (March, 1952), p. 209.

15. *Evolution Emerging,* New York, 1951, Volume I, p. 487. Artifacts might have been necessary for survival if the teeth were human. Wood and other perishable materials could have been used to kill animals. See George A. Bartholomew, Jr. and Joseph B. Birdsell, "Ecology and the Prehominids," *American Anthropologist,* Vol. 55 (October, 1953), p. 490.

16. In his "Taxonomy and Human Evolution," *Yearbook of Physical Anthropology for 1950,* pp. 221-271 (Reprinted from *Biological Reviews,* Vol. 25) Zuckerman appears to have contributed one of the most scholarly criticisms of the Dart-Broom-Robinson school yet to appear. It is unfortunate, however, that he attempted to belittle Gregory's evaluation of Australopithecus by referring to him as the sponsor of an alleged primate fossil tooth later identified as that of a peccary (p. 228). Gregory challenged this erroneous identification from the start as the present writer pointed out in his *Man's Unknown Ancestors,* Milwaukee, 1948, p. 17.

17. *Origin and Evolution of Man,* Cold Spring Harbor Symposia on Quantitative Biology, Cold Spring Harbor, N. Y., 1950, p. 111.

18. *An Appraisal of Anthropology Today,* edited by Sol Tax et al., Chicago, 1953, pp. 262-263.

cranial cases to phrenology. Oakley urged a new working definition for identifying fossil man: "the tool-making hominid." [19]

3. *Posture.* Where evidence of artifacts is lacking paleontologists seem to be paying more attention to posture as a mark of fossil man today. Such emphasis is based upon the assumption that man may have arrived "feet first." Upright posture which freed hands for making artifacts can be identified in the pelvis as well as in other skeletal parts, such as the base of the skull, it is said. Gregory believes that the Australopithecine skeletons "indicate an erect posture" [20]; a similar viewpoint was expressed at the Cold Spring Harbor Symposia by S. L. Washburn, W. W. Howells, Adolph Schultz, and Ernst Mayr among others.[21] Even E. H. Ashton and S. Zuckerman recognize this.[22] Yet William L. Straus, Jr., warns against including the Australopithecine in the genus *Homo* on the basis of apparent bipedalism, pointing out that "it is often quite difficult or impossible to establish the precise posture of a fossil primate." [23]

4. *Geological Age.* It seems to be quite generally agreed that the weakest point in the case for Australopithecus is the evidence of geological age. Broom lamented the fact that geologists had given him very little help. A. W. Rogers who made a survey of South Africa in 1925 said there was no probability of determining the age of the deposits. Lacking a geological time-table Broom proceeded to estimate time periods by other factors such as the nature of the animal life found in caves with the fossils. From this he concluded that the deposit in which the earliest fossils were found was Pliocene.[24] Few others, however, are willing to accept this evidence.

We shall not attempt to go into the special difficulties involved in making accurate geological estimates of the Australopithecine habitat. For one thing it is difficult to correlate the African pluvial periods with the European glaciations. Two Americans qualified to give an opinion, Charles L. Camp and George B. Barbour, visited the site recently, and although Barbour seems to be more favorable Camp points out that stratifications are not available and the faunal sequence is not yet worked out. Although Camp regards the site as Pleistocene he found it difficult to separate the Pleistocene from Recent formations.[25]

Little help in dating these fossils is expected from the two new methods, radio-carbon (Carbon 14) and fluorine analysis, at present. Carbon 14 dating cannot be used back beyond 35,000 years. As the deposits were

19. *Ibid.*, pp. 259, 265.

20. *Op. cit.*, p. 486.

21. *Loc. cit.*, pp. 70-83, 111. Teilhard de Chardin also agrees. *Op. cit.*, p. 209.

22. "Some Cranial Indices of Plesianthropus and Other Primates," *American Journal of Physical Anthropology,* Volume 9 (September, 1951), p. 296. W. E. Le Gros Clark agrees but says (with Ashton and Zuckerman) that the head was not balanced as it is in modern man. *A.J.P.A.*, Volume 10 (March, 1952), p. 121.

23. *An Appraisal of Anthropology Today,* p. 263.

24. *Op. cit.*, pp. 35-36.

25. The geological difficulties are described briefly in Barbour's paper, already referred to, and in the comments of Camp and Barbour during the Fourth Summer Session in Physical Anthropology (*1948 Yearbook of Physical Anthropology,* pp. 25-26), also in *Anthropology Today,* A. L. Kroeber et al., Chicago, 1953, pp. 175-180.

indurated by travertine it appears that the fluorine method will not unlock the riddle until the ages of associated specimens are available for comparison.[26] Although Robinson recently stated "From available faunal, geological, and archeological evidence the geological age of the Australopithecines may be fixed with reasonable certainty: the age must be no earlier than upper Pliocene and no later than lower Pleistocene,"[27] he cites no authority for this "reasonable certainty."

Two facts seem to stand out more prominently than any others in the recent literature on *Australopithecus:* (1) the lack of precise knowledge about the age of these fossils and (2) the importance of determining that these fossils are old enough to be "ancestors of man" before drawing any final conclusions about them.

III. Tentative Conclusions

While it is too soon to draw final conclusions about the nature and place of the Australopithecines it should facilitate understanding if at this point we consider a few brief summations made recently by competent authorities. We shall consider here only three. The first, by William L. Straus, Jr., an anatomist, summarizes the difficulties faced in attempting to evaluate the fossils.

> Their geological age is highly uncertain. The exact character of their habitat has not been established. To some students their posture remains a reasonable doubt. The phylogenetic significance of some of their morphological characters is open to different interpretations. The view has been expressed that much of the material needs to be more thoroughly studied and evaluated, particularly by comparison with statistically significant series of other primates. The meaning of the curious giant forms is quite obscure. The enthusiastic attempts to reconstruct the social life of the *Australopithecinae* have not been calculated to inspire confidence. In short, many important questions remain to be answered. The great quantity of Australopithecine material thus far uncovered, and the prospect of still more to come, betokens years of careful study.[28]

From the viewpoint of physical anthropology we have the tentative conclusion of M. F. Ashley Montagu:

> In the present stage of our knowledge one can only point to the australopithecines and say, that while no one of them may have been directly ancestral to man, a type very like them must have been; which is to say that the manlike apes from South Africa are man's nearest present known relatives, and that there may have been one or more stages of development between a form like them and the appearance of the first man. There cannot have been, however, more than a few such intermediate stages for the australopithecines have themselves almost made the passage into the family of man, the Hominidae . . .[29]

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26. OAKLEY, KENNETH P., "Dating Fossil Human Remains," *Anthropology Today,* pp. 49-53.

27. "Meganthropus, Australopithecines, and Hominids," *A.J.P.A.,* Volume 11 (March, 1953), p. 32.

28. "Primates," *Anthropology Today,* pp. 89-90.

29. *An Introduction to Physical Anthropology,* revised, Springfield, Ill., 1951, p. 121.

Finally we have the opinion of Pierre Teilhard de Chardin, a paleontologist, who has made a first-hand study of both the early Asiatic and South African fossils:

> . . . the Australopithecines differ from all living and fossil Apes known so far, and they are strongly hominoid ('hominoid' however does not mean 'human'). In no case . . . can the Australopithecines (in contrast to the Pithecanthropines) be considered as a zoological group which, at any time, crossed the divide between Ape and Man.[30]

It may be relevant to add as a final observation that Teilhard de Chardin is now convinced that Africa, rather than Asia, was "the main laboratory for the zoological development and the earliest establishment of man on this planet." [31]

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30. *Op. cit.*, p. 209.

31. "The Idea of Fossil Man," *Anthropology Today*, p. 96. He points out that in addition to the Australopithecines this continent is also the source of the higher types of fossil Primates and a wealth of widely distributed older Paleolithic industries. In this connection it might be mentioned that the matter of the possible relationship of the Australopithecines to the lower Miocene fossil apes from Kenya (*Proconsul* and *Limnopithecus*) was considered to be beyond the scope of this paper.

Possible New World Affiliations of the Neolithic Baikal People

Ben R. Huelsman, Indiana University

Of the few well-documented archaeological skeletal series of Siberia, the Neolithic Baikal Type "A" population is of considerable interest because of its widespread ramifications in both Siberia and northwestern North America. This Neolithic population was first described by the Russian physical anthropologist, G. F. Debetz as a result of his examination of a series of skulls from the late neolithic of the Transbaikal region. It is apparent, as Debetz himself recognized, that this neolithic Siberian population resembles somewhat the contemporary Aleut. If the Pre-Aleuts are compared with the Baikal populations, however, the resemblances are even more striking.

The Neolithic Baikal population and the Pre-Aleuts share the following traits: the vault is absolutely long, narrow, and low, the forehead is very sloping, the brow-ridges are moderate in development, and the cranial index is dolichocranial. For both groups the face is typically long and moderately broad in its absolute dimensions; both populations are leptoprosopic, the upper facial index being mesene; the nasal index is leptorrhine and the orbital index is hypsiconch.

The later Aleut population differs from the Baikal people in being broader and shorter vaulted, the cranial index falling into the brachycranial index class. With reference to facial dimensions and profile, however, the present-day Aleut are skeletally still quite close to the Siberian group. The Eskimo also disclose a facial similarity close to the Neolithic Baikal population, but these resemblances are limited to the face. The Neolithic Baikal population is characterized by an extremely low mean cranial height which is apparently due to platybasia, while the Eskimo are one of the most high vaulted groups in North America. The great resemblance between the Neolithic Baikal population and the Pre-Aleut suggests that this Siberian group is directly ancestral not only to the Pre-Aleut but also to the Deneid variety.

Since the Neolithic Baikal population probably did not give rise to the Eskimo or Inuid variety, it is suggested that the common ancestral group to both of these populations is to be discovered among some yet unknown pre-neolithic mongoloid population of northern Siberia.

The distribution of the low-vaulted Baikal type in Siberia is very widespread and throws additional light on the problem of racial differentiation in both Siberia and North America. The Tungus of Northern Baikalia most nearly resemble the ancestral neolithic Baikal population, and are closely followed by the Lamut of northeastern Siberia. Brachycephalized descendants of the Baikal population occur also in Central Asia and can be considered to comprise the Evenkid variety. This variety is represented among the Buriats, Kelmyks, Mongols, Telengets, and Tuvinians, and in the Amur region among the Oroki, Orochi, and especially the Gilyaks. All these Evenkids share, along with the Aleut, and in general the Deneid variety, the following traits: the vault is broad and low in absolute dimensions, the cranial index being brachycranial in every case,

the forehead is typically less sloping and the brow-ridges less developed than among the neolithic Baikal population. All of the later groups enumerated share a number of facial resemblances, both in absolute dimensions and in indicial relationships. For all these groups the characteristic combination is hypsiconchy, meseny, and mesorrhiny.

In reconstructing the racial history of this branch of the Asiatic subspecies of man it is necessary to take into account not only craniological similarities but also somatological resemblances and differences. On the whole the groups which remained in Siberia, especially in Central Asia and the Amur, exhibit a greater degree of mongoloid specialization in their facial features, especially in the frequency of appearance of the epicanthic fold among these groups. On the other hand, the Aleut, and in general the Deneid variety, are more generalized, the faces of the living are less mongoloid-appearing and the epicanthic fold occurs less frequently than among the Asiatic branch of the Baikal stock.

The Deneids and Aleuts probably are more like the group which was ancestral to the Central Asiatic populations than are those populations themselves today. One has only to envisage this more conservative strain of the Baikal population wandering off to northwestern Canada, while other groups remained behind in Asia, eventually reaching Central Asia, the Amur and gradually filling up the vast expanse of the Siberian taiga, where they interbred with other mongoloid populations to give rise to many of the local types present in the anthropological composition of the peoples of northeastern Asia. Not all of those who remained behind in Asia became brachycephalized and acquired the broad, fat-padded faces typical of Buriats, Mongols, Gilyaks, etc. One such conservative group, which has preserved more or less unchanged the features of its ancestral neolithic Baikal stock are the present-day Tungus of Northern Baikalia. The extreme conservatism of this Tungusic group is revealed by the fact that they are today as close to the cranial type of the Pre-Aleuts as they are to the cranial type of the modern Aleut.

Within the Evenkid variety there are the conservative Tungus of Northern Baikalia on the one hand, and on the other, the more specialized Mongols, Buriats, Telengets, Tuvinians, and Kalmyks, in addition to the Gilyaks. The great similarity between the members of the Evenkid variety in Siberia and the Pre-Aleuts and Deneids in North America suggests that all three of these groups are directly related to the neolithic Type "A" population of Baikalia.

The question now remains: What of the relationship between the physical type of the Eskimo and that of the Neolithic Baikal people? In the case of the Pre-Aleut to Aleut sequence, it has been shown that the earlier Pre-Aleut population, which is closer in time to the neolithic Baikal population, is also anthropologically closer to the Siberian population. If the Eskimo are to be derived from this Siberian group, then it is to be expected that an early Eskimo group should exhibit similarities with the supposedly ancestral Siberian population.

A comparison of the Old Igloo series of Eskimo crania with those of the Baikal type shows that the Eskimo group differs considerably from the Siberian group in the following traits:

The vault of the Eskimo series is typically much higher and narrower, the cranial index is more dolichocranic, the total facial breadth exceeds that of the Siberian series, and the forehead is less sloping. In general the few resemblances between this ancient Eskimo population from western Alaska and the Siberian neolithic Baikal population are no greater than the difference between the Contemporary Greenland Eskimo and the neolithic Baikal people. Not only does the Inuid variety differ from the neolithic Baikal population, but they also differ markedly from the Pre-Aleuts, Aleuts, Deneids, and Evenkids of Siberia. The typological evidence suggests that the Pre-Aleut and Eskimo populations of the New World represent two distinct population movements to North America and that the differentiation between the Pre-Aleut and Inuid stock took place in northern Siberia, probably long before either group migrated across Bering Strait.

A Vanderburgh County Site with Southern Affinities

FRANCES PATTON MARTIN, Newburgh

A prehistoric Indian site, designated as Vg 44, is located in the southeastern section of Vanderburgh county, Indiana, on a low ridge in the flood plain of the Ohio river. Surface collections have been made from there for the Indiana Historical Society since April, 1950, and consist of 1,149 sherds, some daub and 372 worked stone specimens and lithic samples. In this assortment are indicators of occupation by Mississippi, Yankeetown, Middle Woodland and probably Early Woodland groups.

This site is important because its ceramic range includes some pottery types which are unusual for this area. Sherds were found there which have granular temper and complicated stamp designs typical of wares of the southeastern states with Georgia as the center of their distribution. Some other sherds collected at Vg 44 are clay tempered with incised lines enclosing rocker marking and dentate stamping identical to Marksville types of the lower Mississippi valley. In addition a bowl rim sherd was found with a distinctive wide flat lip which is a duplicate of a rim type found on lower Mississippi valley sites where Marksville sherds are present.

This marks the second finding in Vanderburgh county of complicated stamp sherds. A few were found previously at the Angel site, (1) which is two miles east of Vg 44. However, those sherds, regarded as trade items, were identified as Lamar ware and are chronologically later than the ones at Vg 44. The only other place in the area where complicated stamp sherds have been found is 22 miles southwest of Vg 44 in Posey county, Indiana, at the Mann site (2) and a continuation of it, designated as Po v14 (3). There the complicated stamp wares are said to resemble Swift Creek and Napier types most closely and the same statement can be made about the sherds found at Vg 44. Sherds with lower Mississippi valley affinities like those mentioned previously as being found on Vg 44 are also found at Mann. In addition the Mann site has Hopewell material which is not found on Vg 44. A discussion of the other exotic features of the Mann site are not pertinent to this paper.

The ever increasing number of sherds of Swift Creek, Napier and Marksville wares that have been found on the Mann site since Adam's report was written plus the finding of their duplicates on Vg 44 presents a new perspective from which we can view these complexities and raises the question as to whether we can regard pottery in such quantity as all having been brought in from the south. This is all conducive to the speculation that possibly the pottery types in question were not brought into Indiana as trade ware but were actually made in Indiana. In view of the known far reaching trade activities of the Hopewell people is it not conceivable that the Mann site was a trading center? Therefore, we might expect that men coming there from the south on trading expeditions would be accompanied by their women who in the course of their stay at the site might make some of their native pottery. Another possibility would be that of southern women going to Indiana with traders from the

Mann site to live there and continue the use of the ceramic techniques of their homeland. A third contingency is that people of Swift Creek and Marksville affinity actually lived at Mann and Vg 44 and other as yet unknown sites in this portion of the Ohio valley.

If we accept any of these three hypotheses, we might go even a step farther and concede that the supposedly alien sherds at Vg 44 might have been made there since alien people were present in the vicinity rather than arbitrarily deciding that they are trade ware from Mann.

In conclusion let me state that my arguments apply only to what might have taken place in southwestern Indiana. As far as the writer is concerned trade ware in most cases rather than tradeswomen is still a valid explanation for pottery seemingly out of place geographically.

Literature Cited

1. BLACK, GLENN A. Trait complexes at the Angel Site, Proceedings of the Indiana Academy of Science, Vol. 51, 1942, p. 43.
2. ADAMS, WILLIAM R. Archaeological notes on Posey County, Indiana. Indiana Historical Bureau, 1949, pp. 47-66.
3. *Ibid.*, pp. 73-75.

BACTERIOLOGY

J. O. MacFarland and L. S. McClung, Chairmen

Dorothy Powelson, Purdue University, was elected chairman for 1954

ABSTRACTS

Intracellular inclusions in a *Caulobacter* sp. E. A. Grula and S. E. Hartsell, Purdue University.—Throughout the long history of bacterial cytology, numerous observations have been made relating to the chemical nature of bacterial inclusions. Such studies continue today with a seemingly unending array of claim and counter-claim. It should be pointed out that most of the critical studies relating to such inclusions have been performed with optical instruments.

Beginning with a standard electron microscope technique, we have modified some preparational procedures thereby permitting us direct observation of intracellular inclusions before and after specific extraction and digestion procedures, after growth on optimal and minimal synthetic media and in "specific-action" buffer solutions wherein one inclusion was synthetized "de novo" by the cells.

Where necessary, ordinary staining in conjunction with optical instruments have been employed.

Studies relating to dark and dense intracellular granules have been performed utilizing the O/R indicator dye 2, 3, 5 triphenyl tetrazolium chloride. Its intracellular reduction has been correlated with the presence or absence of the dark inclusion.

A further note will be supplied regarding fixation techniques in relation to extraction procedures.

An experimental study of the nature of bacterial pyrogens. Paul D. Ellner, University of Southern California (Now at Indiana University).—Factors influencing the production of pyrogen by two strains of *Pseudomonas aeruginosa* were studied. Experimental results indicate that 37 C approaches the optimum temperature for pyrogen production, at a neutral pH. Pyrogen is best produced on a medium in the slightly oxidized state. Media containing small amounts of sodium chloride appear to be stimulatory to pyrogen production which begins at the phase of logarithmic growth. Although the pyrogen is non-antigenic, when the bacterial cells of a pyrogenic species are suspended in specific antiserum (agglutinin), no demonstratable amounts of pyrogen are produced. Pyrogen appears to be intimately associated with the cell substance, rather than being a diffusible metabolite of the intact living cell. It is concluded that bacterial pyrogen produced by this species is associated with the cell substance, analagous to an endotoxin, and is released into the surrounding medium by cellular autolysis. Environmental conditions such as temperature, pH, O-R potential and chemical composition of the medium, which tend to stimulate cell proliferation are also conducive to the elaboration of pyrogen, since the number of autolyzed cells increases with increasing age of the cultures.

A synthetic medium for candicidin production. R. F. ACKER, Purdue University, (work done at Rutgers University).—An investigation of the nutritional requirements of *Streptomyces griseus* 3570 showed that L-asparagine and L-histidine were utilized to best advantage as sources of nitrogen for the production of the antifungal antibiotic, candicidin. Ammonium salts and nitrates were found to be poorly utilized. Among the carbon sources tested, glucose and mannose gave better antibiotic yields and growth than other sugars, sugar alcohols, or organic acids. However, certain organic acids supplied as sodium salts, e.g. sodium lactate and sodium malate were stimulatory when supplied to supplement glucose. Sodium lactate, with glucose, gave maximum candicidin yields, and sodium malate, with glucose, gave maximum mycelial growth.

The macroelements potassium magnesium, phosphate-phosphorus, and sulfate-sulfur were found essential to candicidin production, inasmuch as they were essential to growth. Such proved also to be the case with the microelements iron and zinc. It could not be demonstrated that manganese was required by culture 3570 either for growth or candicidin production.

The above findings led to the formulation of a synthetic medium for candicidin production containing L-asparagine, glucose, sodium lactate, magnesium sulfate, dibasic potassium phosphate, iron, and zinc. Potencies produced in this medium were of an order of 8 to 10 thousand dilution units per ml by streak-dilution assay, as compared with 10 to 20 thousand dilution units per ml produced in the complex production medium.

Microscope studies of red blood cell agglutination. JOSEPH CARLIN and MERWIN MOSKOWITZ, Purdue University.—Several workers have presented evidence that the addition of agglutinins to red cells brings about alterations of the red cell surface and have suggested that the resulting agglutination is due to these alterations.

Red cell agglutination was studied using both light and electron microscopy and it was observed that under the proper conditions agglutination occurred without detectable surface changes, and also that the alterations described by the other workers could be produced in the absence of agglutinins.

This study demonstrated that red cell agglutination occurs independently of alterations of the surface of the cells, giving support to the lattice theory that aggregates are formed by combination of specific groupings on the cell with specific groupings on the multivalent antibody.

Phenol extraction of the red cell altering factor of Streptococci. MERWIN MOSKOWITZ, BARBARA THOMPSON and ALEXANDER SONNENWIRTH, Purdue University.—Studies have been under way in this laboratory on the separation of the antigen(s) of *Streptococcus pyrogenes* that alter red cells in such a manner that they are agglutinated by normal human serum. A method has been found to extract the altering factor with phenol. Many difficulties were encountered in working with phenol in order to obtain consistent results. Impurities in phenol preparations, changes occurring in phenol on standing, and the phase relationships between phenol and water caused complications. The present method of extracting the altering factor and further steps in its purification will be discussed.

The effect of 2,4-diamino-5-p-chloro-phenyl-6-ethylpyrimidine in experimental toxoplasmosis. W. A. SUMMERS, Indiana University Medical School.—Low diet concentrations of Daraprim (0.01 per cent) did not prevent the death of *Toxoplasm*-infected mice nor alter the development of the parasite in the host. Higher but clearly toxic dosages of Daraprim (0.075 and 0.1 per cent) prevented the development of *Toxoplasma gondii* and protected a large percentage of infected white mice. The addition of pteryolglutamic acid to the Daraprim diet did not reverse the anti-toxoplasmal action of Daraprim and appeared to lessen the toxic action of the latter for the animals. Judging by the methods used, Daraprim did consistently eradicate Toxoplasma from the brain, spleen, liver and lungs of mice that received small to moderately heavy inocula of this parasite.

Tracer studies on threonine biosynthesis and metabolism by *Neurospora* mutants. HAROLD R. GARNER, Purdue University.—Biochemical and genetic studies of the threonine-less series of mutants of *Neurospora* have led to an accumulation of data some of which cannot be reconciled with other. No single scheme of reactions has yet been capable of explaining the biochemical needs and genetic interrelationships of these mutants. An attempt is being made to untangle this information by using C^{14} labeled compounds to trace reaction sequences.

Strain 35423 was grown on uniformly labeled glucose and unlabeled threonine. The mycelium was hydrolyzed, the individual amino acids separated by column chromatography and their specific activities determined. The results show that the unlabeled threonine is used directly and also acts as a precursor of isoleucine. Slight variations in specific activity of other amino acids can probably be explained as due to CO_2 fixation since degradation of the aspartic acid from these cells showed an average of one carboxyl group per molecule to be unlabeled. Similar experiments with two other mutants have confirmed homoserine as a precursor of threonine. However, homoserine does not appear to be a direct precursor of methionine as it appeared from previous work. To check this point further, uniformly radioactive cystathionine was biosynthesized and is being used to support the growth of a cystathionine-less mutant.

It is hoped that this work will provide a solid biochemical reaction scheme around which to explain the genetic deficiencies of the mutants.

The electron microscopy of the lysis of *M. lysodeikticus* with lysozyme. E. A. GRULA and S. E. HARTSELL, Purdue University.—Since the discovery of lysozyme in tears by Fleming, there have been several publications relating to the "modus operandi" of this mucolytic enzyme on bacterial cells. The test organism has, in most instances, been *M. lysodeikticus*—the organism originally employed by Fleming.

In the days prior to the electron microscope, several lively controversies developed regarding lysis of this organism with lysozyme. The arguments were concerned primarily with swelling—a phenomena still mentioned, but as yet unresolved, in today's literature.

With the advent of the electron microscope, the possible disruption or digestion of the cell "per se" has also been of prime concern. Unfortunately, more conflicting data has appeared concerning the lysis of this organism.

In studies performed in these laboratories, we have attempted to obtain a correlated and accurate picture of the lytic phenomenon using both the light and electron microscopes. Also currently improved techniques relating to electron microscopy, that is the "freeze-dry" method has been employed.

As an adjunct to these techniques, live cells of *M. lysodeikticus* have been subjected to disruption with glass beads in order to follow further the effect of lysozyme on cellular structures.

The genus *Clostridium*—advances in the last decade. L. S. McCLUNG, Indiana University.—Recent contributions were reviewed concerning the study of the anaerobic organisms including summary of information on purification of the toxins produced by organisms causing botulinum, lock jaw, and gas gangrene. The success of toxoid immunization in tetanus and the availability of toxoids for gas gangrene and botulism was reported. The problem of classification of the clostridia was discussed and mention was made of the many new species reported recently for the genus *Clostridium.* Additional topics in which recent investigations have proved fruitful include: cellulose fermentations including microflora of the rumen, and mechanism of metabolism of anaerobic reactions.

Recent advances in the preparation of antirabies vaccines containing inactivated virus. H. M. POWELL and C. G. CULBERTSON, Lilly Research Laboratories, Indianapolis, U. S. A.—The common methods for inactivating fixed rabies virus in the preparation of vaccine have included (a) natural or spontaneous aging, (b) common antiseptics such as phenol in the presence of variable amounts of heat, (c) ultraviolet irradiation, and (d) certain nitrogen mustard or mustard-like drugs.

An early but very brief report on the use of a mustard compound in fixed rabies virus was by C. Tenbroeck and R. M. Herriot, *Viruses inactivated by mustard (Bis (B-chloroethyl) sulfide)* as vaccines. Proc. Soc. Exp. Biol. and Med. 1946, 62, 271-272. It appeared that these investigators secured better antirabic immunity in guinea pigs injected with such vaccine than with vaccine treated with phenol or chloroform. A further report by the same authors was *Mustard inactivated rabies vaccine.* Proc. Soc. Exp. Biol. and Med. 1950, 75, 523-528.

We have had occasion to try out twenty-five nitrogen mustard or mustard-like drugs for inactivating fixed rabies virus in the preparation of anti-rabies vaccine. Some of these drugs expend themselves very rapidly in dilute aqueous solutions while others last for several days or weeks. A reasonable time for inactivation of fixed rabies virus in the ice box was arbitrarily set at five to seven days or less, although some of the drugs accomplish inactivation at some time during the second or early in the third week. Slow inactivation apparently may be due to innate inertness on the one hand, or to very rapid disappearance of the drug on the other hand, necessitating a complicated repeated drug treatment of virus.

Five drugs of considerable interest in this group were as follows:

(1) 00915 B B' dichloroethylamine
(2) 01749 1 morpholino, 2,3, epoxypropane
(3) 01995 butadiene monoxide

(4) 01401 benzyl B-Chloroethylamine
(5) 01621 N(2-hydroxyethyl) ethylene imine

Rabies vaccines made by addition of from 1 to 3 mgm. of drug per ml of virus and let stand in the ice box for complete inactivation have given the following results on immunization of mice by present standard NIH methods:

(1)	vaccine mice LD_{50}	$10^{-3.1}$
(2)	" " "	$10^{-3.3}$
(3)	" " "	$10^{-4.5}$
(4)	" " "	$10^{-2.0}$
(5)	" " "	$10^{-2.0}$
Commercial vaccine 433668		$10^{-2.0}$
Control mice (no vaccine)		$10^{-6.0}$

Drug number 2 has been used to inactivate fixed rabies virus propagated in embryonated duck eggs (Powell, H. M., and Culbertson, C. G. *Cultivation of fixed rabies virus in embryonated duck eggs.* Public Health Reports 1950, 65, 400-401) and vaccine made in this has given protection to mice against about 26,000 LD_{50} of active virus.

BOTANY

Chairman: DANIEL DEN UYL, Purdue University

RICHARD STARR, Indiana University, was elected chairman for 1954

ABSTRACTS

Notes on the vascular flora of Fountain County, Indiana. FRANKLIN B. BUSER, University of Illinois.—Specimens of 261 species of vascular plants, previously unrecorded for Fountain County, have been deposited in the University of Illinois Herbarium. These, plus six specimens of other collectors deposited in the same herbarium, bring this county's total of vascular plant species to 942. Tabulation and nomenclature is based, mainly, on that of Deam's *Flora of Indiana*. Three adventive species have been recorded as first state reports in Indiana Plant Distribution Records.

Responses of *Marsilea mucronata* to nutrient concentrations. WILLIAM W. BLOOM, Valparaiso University.—Sporocarps of *Marsilea mucronata* were germinated in various concentrations of a balanced nutrient solution and the effect upon gametophyte and sporophyte development noted. The best early development occurred in solutions weaker than the usual greenhouse nutrient solutions but very weak solutions were detrimental to good development.

Experiments on the relative production of fertile achenes by ray and disc florets in some Astereae. ALBERT L. DELISLE, Notre Dame University.—In the Aster species studied, although there are more disk than ray florets, the ray florets produce the greater number of fertile achenes (2 to 1). Controlled pollination of several species also indicates a higher production of fertile achenes by the ray florets than by the disc florets in the same capitulum. Similar results obtain in the open pollination of these same species. The fertile ray florets make up 59.0% of the total fertile flowers per capitulum. The stigmas of the ray florets are receptive over a longer period of time than those of the disc florets. In controlled pollination, it is suggested that solely the ray florets be utilized as the female parent. This method is rapid, dependable and seems to assure the largest number of achenes. For this purpose, a cloth-covered wire, pollen applicator, circular in form and of a diameter slightly larger than the area covered by the disc florets, has proved very successful for mass pollination in these asters.

The use of an easel and colored chalk in teaching. S. N. POSTLETHWAIT, Purdue University.—Prof. Eric Sharvelle has used colored chalk and easel to present experiment station information to various types of audiences and has found this technique to be an effective teaching aid. The same technique has been used by the author in the classroom with favorable results. The idea is to prepare drawings and cartoons with colored chalk which will specifically illustrate the point the instructor desires to present and these illustrations are then brought to the classroom

to be used in conjunction with the lecture. This permits the instructor to make carefully the drawings which he would normally do on the blackboard during the lecture. Some advantages of the technique are that the illustrations will be of better quality, more accurate, and they can be stored for future use.

The Pasteur effect in corn. MARY JANE NEAL and RAYMOND E. GIRTON, Purdue University.—Oxygen uptake, carbohydrate loss, alcohol and carbon dioxide production were measured in corn root tips respiring under aerobic and anaerobic conditions. An attempt was made to balance the substrate carbon loss with the carbon in the end products of respiration and fermentation, and to compare the rates of carbohydrate loss in air and in nitrogen.

The respiratory quotient of the root tips respiring in air was approximately 0.86. This together with the fact that slightly more carbon dioxide was produced than was necessary to balance the carbohydrate loss indicates the utilization of some compounds other than carbohydrates as respiratory substrates.

The carbohydrate loss of roots in nitrogen for a four hour period was about 35 per cent greater than that of roots in air for the same period. This increased sugar loss under anaerobic conditions is evidence for the existence of the Pasteur effect, which may be defined as the action of oxygen in diminishing carbohydrate destruction.

The ratio of alcohol to carbon dioxide (expressed as milligrams) produced in nitrogen ranged from 0.64 to 0.96, indicating that some carbon dioxide was produced in excess of that from alcoholic fermentation. A part of this excess carbon dioxide is from the fermentation of substrates other than carbohydrates. Only approximately 88 per cent of the anaerobic carbohydrate loss may be accounted for by alcoholic fermentation. This is indicative of the existence of one or more other anaerobic pathways of sugar breakdown in corn root tissue.

New Indian Species of *Synchytrium*. B. T. LINGAPPA, Purdue University.—Thirteen new species from India are described as follows:

1. *Synchytrium launeae* on *Launea asplenifolio* Hook. f.
2. *S. phyllanthi* on *Phyllanthus simplex* Retz and *P. urinaria* Linn.
3. *S. thirumalachari* on *Atylosia scarabeoides* Bth.
4. *S. crustatum* on *Indigofera enneaphylla* Linn. and *I. liniola* Retz.
5. *S. viticola* on *Vitis trifolia* Linn.
6. *S. zorniae* on *Zornia diphylla* Pers.
7. *S. oroxyli* on *Oroxylon indicum* Linn.
8. *S. trichodesmatis* on *Trichodesma indicum* R. Br.
9. *S. maculans* on *Sida rhombifolia* Linn.
10. *S. cassiae* on *Cassia pumila* Lam.
11. *S. oldenlandiae* on *Oldenlandia corymbosa* Linn.
12. *S. biophyti* on *Biophytum reinwardtii* Edg. & Hook. f.
13. *S. rhynchosiae* on *Rhynchosia aurea* DC.

A short diagnosis of each species is given and selected photographs of macroscopic and microscopic characters are provided. Out of 13 new species 10 have long cycle of development comprising of Prosori, sporangia

and hypnospores and the other three have only hypnospores being short-cycled.

The evolution of certain segments of the North American Euoenothera population. RALPH E. CLELAND, Indiana University.—In the course of its evolution, *Oenothera* has experienced many interchanges of segments between non-homologous chromosomes. It is possible, by analyzing the interchanges which have occurred in the evolution of individual races, to trace the phylogenetic pathways which have led to the various races now found in nature. The present paper describes the way in which the *biennis* and *strigosa* populations have come into existence. These groups arose as a result of crossing between overlapping populations which had arisen at different times and which had experienced radically different histories of interchange. These crosses produced plants with large circles of chromosomes, a condition which has survived to the present day. The presence of large circles gave survival value to the presence of lethals and to the self-pollinating habit which are characteristic of present-day forms, and which together are the cause of the peculiar genetical behavior and the unique type of population structure for which *Oenothera* is noted.

***Palmoxylon* from Eden Valley, Wyoming.** MARGRET SCHNAITMAN, University of Cincinnati.—Silicified specimens of monocotyledonous woods from an upper Lower Eocene formation are referred to the genus *Palmoxylon* Schenk. The following species are recognized: *Palmoxylon texense* Stenzel, *P. parvifasciculosum* Vater, *P. astron* var. *verum* Stenzel, *P. Rutoti* Stockmans and Williere, and *P. cellulosum* Knowlton. One new species, *P. elongatum*, is described. All species are new reports from Eocene formations: two, *P. parvifasciculosum* and *P. Rutoti*, are new reports from North America. *Palmoxylon* is an unnatural genus including species which have been referred to the Palmae and Cyclanthaceae, while other species may belong to additional families. Both specific identification and family reference are extremely difficult due to the absence of adequate knowledge of comparative anatomy of extant monocotyledons.

Indiana Plant Distribution Records, XIV. 1953.

Genera are listed in the order used in Deam's Flora of Indiana, and species are given alphabetically within the genera. Symbols following the county in which specimens were collected indicate the herbaria in which confirming specimens have been deposited. IU, B and I stand for Indiana University, Butler University and the University of Illinois respectively. Entities considered worthy of being newly listed as part of the state's natural or adventive flora are given in bold face followed by literature reference and name of collector. Nomenclature is, with a few exceptions, in accord with that used in Gray's Manual of Botany, 8 ed., 1950. In the case of the exceptions, the Gray's Manual name is given parenthetically.

Specimens have been collected by the following collectors: Harry E. Ahles, Franklin B. Buser, Agnes Chase, Charles C. Deam, Charles Ek, Ray C. Friesner, Jon Hall, E. J. Hill, G. N. Jones, O. E. Lansing, W. S. Moffatt, Rose Overstreet, John E. Potzger, Helene Starcs, L. M. Umbach, J. R. Weir, and Nancy G. Willis.

A card file is maintained at the Botany Department of Butler University showing published distribution of each entity within the state. Anyone in need of such information may obtain it from this file.

Taxonomic Entities

Dryopteris noveboracensis, Fountain (I, IU). *Typha angustifolia*, Fountain (I). *Sparganium eurycarpum*, Parke (I). *Potamogeton illinoensis*, Fountain (I). *Zannichellia palustris*, Fountain (I). *Bromus japonicus*, Fountain (I, IU, B). *B. latiglumis*, Morgan (I). *B. purgans*, Fountain (I). *B. secalinus*, Greene (B). *B. sterrilis*, Clark (I, IU, B). *Festuca elatior*, Fayette (I). *Glyceria septentrionalis*, Fountain (I, IU, B). *G. striata*, Fayette (I). *Poa compressa*, Fayette (I). *Eragrostis cilianensis*, Pulaski (B). *E. frankii*, Fountain (I). *E. hypnoides*, Fountain (I, IU, B). *E. spectabilis*, Pulaski (B). *Diarrhena americana*, Fountain (I). *Phragmites communis*, Fountain (I). *Melica nitens*, Fountain (I, IU, B). *Triodia flava*, Cass (B). *Agropyron repens*, Fountain (1), White (IU). *A. smithii*, White (B). *Elymus villosus*, Monroe (IU). *Hordeum jubatum*, Fountain (I). *H. pusillum*, Floyd (I). *Sphenopholis obtusata*, Fountain (I). *Danthonia spicata*, Fayette (I). *Agrostis perennans*, Wayne (B). *Alopecurus aequalis*, Fountain (I, IU). *A. carolinianus*, Martin (I, IU). *Phleum pratense*, Fayette (I). *Muhlenbergia schreberi*, Wayne (B). *M. sobolifera*, Fountain (I, IU, B). *M. tenuiflora*, Crawford (B), Daviess (B), Ripley (B). *Sporobolus asper*, Fountain (I). *S. cryptandrus*, White (IU). *S. heterolepis*, Tippecanoe (B). *S. vaginiflorus*, Fountain (I), Montgomery (I). *Stipa spartea*, Fountain (I, IU, B). *Eleusine indica*, Parke (I). *Spartina pectinata*, Fountain (I). *Bouteloua curtipendula*, Fountain (I, B). *Phalaris arundinacea*, Fountain (I). *Leersia oryzoides*, Fulton (B), White (B). *Digitaria ischaemum*, Fountain (I), Parke (I). *Leptoloma cognatum*, Fountain (I). *Paspalum pubiflorum* var. *glabrum*, Crawford (B), Vanderburgh (I, IU, B). *P. stramineum*, Pulaski (B). *Panicum agrostoides*, Fountain (I), Parke (I). *P. capillare*, Daviess (B). *P. commutatum*, Ripley (B). *P. gattingeri*, Cass (B), Fountain (I). *P. latifo-*

lium, Parke (I). *P. linearifolium*, Fountain (I). *P. polyanthes*, Monroe (IU). *P. scribnerianum*, Fountain (I), Greene (B). *Setaria lutescens*, Wayne (B). *S. viridis*, Henry (B). *S. faberii*, Warren (I). *S. verticillata*, Fountain (I). *Cenchrus pauciflorus (C. longispinus)*, Parke I, Pulaski (B). *Andropogon gerardi*, Parke (I). *A. virginicus*, Fountain (I). *Sorghum halapense*, Fountain (I). *Sorghastrum nutans*, Fountain (I, IU), Fulton (B).

Cyperus aristatus, Fountain (I), Shelby (B). *C. erythrorhizos*, Hamilton (B), Marion (B), Wayne (B). *C. ferruginescens*, Marion (B), Wayne (B). *C. filiculmis*, Fountain (I). *C. flavescens*, Henry (B), Parke (I). *C. ricularis*, Wayne (I). *C. schweinitzii*, Fountain (I). *C. strigosus*, Carroll (B). *C. tenuifolius*, Morgan (B). *Eriphorum angustifolium*, Tippecanoe (I). *Scirpus acutus*, Madison (B). *S. cyperinus*, Parke (I), Wayne (B). *S. flaviatilis*, Fountain (I). *S. lineatus*, Fountain (I). *S. validus*, Fountain (I, B), Parke (I). *Eleocharis acicularis*, Cass (B), Elkhart (B), Fountain (I), Starke (B). *E. calva*, Jay (B). *E. obtusa*, Hamilton (B), Morgan (B). *E. tenuis*, Tippecanoe (I). *Fimbristylis autumnalis* var. *mucronulata*, Marion (B), Morgan (B). *Scleria verticillata*, Tippecanoe (B). *Carex buxbaumii*, Fountain (I). *C. comosa*, Cass (B), Fountain (I, IU, B). *C. crinita*, Fountain (I). *C. cristatella*, Marion (B). *C. emoryi*, Fountain (I), Marion (B), Parke (I). *C. frankii*, Randolph (B). *C. hitchcockiana*, Fountain (I). *C. hyalinolepis*, Fountain (I), Tippecanoe (I). *C. hystricina*, Marion (B). *C. lanuginosa*, Fountain (I). *C. leptalea*, Tippecanoe (I). *C. pennsylvanica*, Fountain (I). *C. plantaginea*, Fountain (I). *C. rosea*, Monroe (B), Parke (I). *C. sartwellii*, Fountain (I). *C. scoparia*, Fountain (I, IU, B). *C. shortiana*, Fayette (I). *C. sparganioides*, Monroe (B). *C. stipata*, Fayette (I). *C. tenera*, Fountain (I). *C. tetanica*, Tippecanoe (I). *C. tribuloides*, Fountain (I), Randolph (B), Wayne (B). *C. virescens*, Fountain (I). *C. vulpinoidea*, Fountain (I), Wayne (B).

Peltandra virginica, Morgan (IU). *Lemna trisulca*, Marion (I). *Commelina communis*, Fountain (I). *Tradescantia ohiensis*, Fountain (I, IU). *T. virginiana*, Parke (I, B). *Juncus acuminatus*, Fountain (I). *J. biflorus*, Fountain (I). *J. dudleyi*, Carroll (B), Fountain (I, IU, B), Hamilton (B), Morgan (B). *J. effusus* var. *solutus*, Fountain (I), Randolph (B). *J. nodosus*, Fountain (I). *J. tenuis*, Carroll (B), Morgan (B), Ripley (B). *J. torreyi*, Madison (B). *Veratrum woodii*, Fayette (I), Fountain (I). *Allium cernuum*, Franklin (I), Warren (I). *A. sativum*, Clark (I, IU, B), Floyd (I, B), Fountain (I), Orange (I, IU). *A. vineale*, Clark (I), Fountain (I). *Lilium superbum (L. michiganense)*, Fayette (I). *Erythronium albidum*, Fountain (I). *Camassia scillioides*, Fountain (I). *Muscari botryoides*, Vermillion (I). *Trillium grandiflorum*, Fountain (I). *T. sessile*, Fountain (I). *Belamcanda chinensis*, Fountain (I), Parke (I), Warren (I). *Cypripedium acaule*, Lake (I). *C. candidum*, Tippecanoe (I, IU, B). *Habenaria lacera*, Fountain (I). *H. psycodes*, Parke (I). *Pogonia ophioglossoides*, Porter (I). *Spiranthes cernua*, Tippecanoe (I). *Goodyera pubescens*, Lake (1). *Liparis lilliifolia*, Lake (I).

Populus alba, Fountain (I). *P. tremuloides*, Ripley (B). *Salix alba*, Fountain (I). *S. cordata*, Vermillion (I). *S. discolor*, Fountain (I). *S.*

sericea, Parke (I). *Quercus imbricaria*, Parke (I). *Urtica dioica*, Parke (I). *Boehmeria cylindrica*, Morgan (IU). *Comandra umbellata (C. richardsiana)*, Parke (I). *Rumex obtusifolius*, Fayette (I). **R. Patientia** L. Gray Man. 8 ed. p. 569. Ill. Flora (1952) v. 2, p. 68. Floyd (I, IU). Collected by Harry E. Ahles and Franklin B. Buser. *Polygonum buxiforme*, Morgan (IU). *P. convolvulus*, Fountain (I). *P. erectum*, Fountain (I), Parke (I). *P. hydropiper*, Fountain (I). *P. lapathifolium*, Fountain (I). *P. orientale*, Fountain (I). *P. tenue*, Fountain (I). *Chenopodium ambrosioides*, Parke (I). *C. glaucum*, Fountain (I, IU). *C. leptophyllum (C. pratericola)*, Fountain (I), Parke (I). *C. standleyanum*, Fountain (I), Parke (I). *Cycloloma atriplicifolia*, Fountain (I). *Atriplex patula*, Fountain (I), Vermillion (I). *A. p.* var. *hastata*, Fountain (I). *Amaranthus hybridus*, Fountain (I), Parke (I). *A. retroflexus*, Fountain (I). *A. tuberculatus* (Moq.) Sauer *(Acnida altissima* and *subnuda)*, Fountain (I). *Froelichia campestris*, Fountain (I, IU, B). *F. gracilis*, Parke (I). *Portulaca oleracea*, Fountain (I). *Stellaria aquatica (Myosoton aquaticum)*, Warren (I, IU). *Arenaria serpyllifolia*, Fountain (I). *Holosteum umbellatum*, Orange (I). *Silene antirrhina* f. *deaneana*, Clark (I). *Dianthus armeria*, Fountain (I). *Saponaria officinalis*, Rush (I).

Nuphar advena, Fountain (I). *Ceratophyllum demersum*, Fountain (I). *Hydrastis canadensis*, Fountain (I). *Cimicifuga racemosa*, Fayette (I). *Aquilegia canadensis* f. *flaviflora*, Fountain (I). *Clematis viorna*, Fayette (I). *Ranunculus micranthus*, Fountain (I, B). *R. septentrionalis* var. *caricetorum*, Parke (I, IU, B). *Menispermum canadense*, Fayette (I). *Dicentra cucullaria*, Vermillion (I). *Corydalis flavula*, Fountain (I). *Lepidium draba*, Clark (I). *Thlaspi arvense*, Fountain (I), Washington (I). *T. perfoliatum*, Floyd (I), Orange (I). *Sisymbrium altissimum*, Fountain (I). **Brassica Hirta** Moench. Deam, Fl. Ind., p. 1051. Fountain (I). Collected by Franklin B. Buser, and, separately, by Harry E. Ahles. *B. nigra*, Fountain (I). *Barbarea vulgaris*, Fayette (I). *Rorippa sessiliflora*, Parke (I). *Nasturtium officinale*, Fayette (I). *Cardamine douglasii*, Vermillion (I). *Camelina microcarpa*, Clark (I). **Neslia Paniculata** (L) Desv. Deam, Fl. Ind., p. 1053. Lake (I). Collected separately by W. S. Moffatt, L. M. Umbach and O. E. Lansing. *Draba verna*, Fountain (I), Vermillion (I). *Descurainia brachycarp*a, Fountain (I). *Sibara virginica*, Martin (I). *Erysimum repandum*, Clark (I), Fountain (I), Warren (I). *Hesperis matronalis*, Harrison (I). *Conringia orientalis*, Fountain (I). *Polanisia graveolens*, Parke (I).

Sedum telephium (incl. *S. telephioides*), Fountain (I). *Heuchera americana*, Fayette (I). *Platanus occidentalis*, Fountain (I). *Crataegus calpodendron*, Fountain (I). *C. crus-galli*, Fountain (I). *C. mollis*, Fountain (I). *C. pruinosa*, Fountain (I). *C. punctata*, Fountain (I). *Fragaria vesca*, Fountain (I), Parke (I). *Duchesnea indica*, Fayette (I, IU, B). *Potentilla simplex*, Fayette (I). *Agrimonia gryposepala*, Fountain (I). *A. parviflora*, Fountain (I). *A. rostellata*, Fountain (I). *Rosa setigera*, Fountain (I). *Prunus persica*, Fountain (I). *Cassia fasciculatus*, Fayette (I), Fountain (I, B). *C. marilandica*, Fountain (I). *C. nictitans*, Fountain (I, IU), Parke (I). *Baptisia leucantha*, Fountain (I). *Crotolaria sagittalis*, Kosciusko (I), Montgomery (B). *Medicago sativa*, Parke (I).

Melilotus officinalis, Fayette (I), Fountain (I). *Trifolium pratense*, Fountain (I). *T. procumbens*, Fountain (I). *Desmodium canescens*, Fountain (I). *D. cuspidatum*, Fayette (IU), Fountain (I), Parke (I). *D. dillenii*, Fountain (I), Parke (I). *D. illinoense*, Fountain (I). *Desmodium paniculatum*, Fayette (IU), Fountain (I), Parke (I). *D. paucifiorum*, Fountain (I, IU, B), Parke (I, IU, B). **Lespedeza bicolor** Turcz. Rehder, Man. Cult. Tr. & Shrubs, p. 520. Fountain (I). Collected by Franklin B. Buser and Harry E. Ahles. *L. capitata*, Fountain (I, B). *L. cuneata*, Fountain (I). *L. intermedia*, Fountain (I). *L. procumbens*, Parke (I). *L. violacea*, Fountain (I, B). *L. virginica*, Fountain (I, IU). *Vicia villosa*, Fountain (I), Parke (I). *Lathyrus palustris*, Fountain (I, IU, B). *Glycine max*, Fountain (I). **Lotus corniculatus** L. Gray Man. 8 ed. p. 896. Ill. Flora (1952) v. 2, p. 398. Fountain (I, IU, B). Collected by Franklin B. Buser.

Geranium carolinianum, Fountain (I). *Ailanthus altissima*, Fountain (I). *Polygala verticillata*, Fountain (I). *Croton monanthogynus*, Fountain (I). *Acalypha gracilens*, Jefferson (IU). *A. rhomboidea*, Harrison (IU). *A. virginica*, Vigo (IU). *Euphorbia cyparissias*, Fountain (I). *E. esula*, Orange (I), Vermillion (I, IU, B). *Callitriche heterophylla*, Fountain (I). *Rhus vernix*, Fountain (I). *Ilex verticillata*, Fountain (I), Wayne (I). *Acer nigrum*, Fountain (I). *Abutilon theophrasti*, Fayette (I). *Althaea rosea*, Fountain (I), *Hibiscus militaris*, Fountain (I). *Lechea tenuifolia*, Fountain (I, B). *Viola affinis*, Fountain (I). *Viola rafinesquii (V. kitaibeliana)*, Fountain (I), Parke (I). *Optuntia humifusa*, Clark (I), Fountain (I). *Rotala ramosior*, Fountain (I). *Ammannia coccinea*, Fountain (I), Vermillion (I). *Peplis diandra*, Fountain (I). *Lythrum alatum*, Fountain (I). *Cuphea petiolata*, Fountain (I). *Ludwigia palustris*, Wayne (I). *L. polycarpa*, Fountain (I). *Oenothera laciniosa*, Fountain (I). *O. pilosella*, Fountain (I). *Gaura biennis*, Fayette (I). *Chaerophyllum procumbens*, Fountain (I). *C. tainturieri*, Orange (I), Washington (I). *Conium maculatum*, Fountain (I). *Zizia aurea*, Fountain (I). *Thaspium trifoliatum*, Fountain (I, B). *Cornus canadensis*, Lake (I). *Cornus racemosa*, Fountain (I), Parke (I). *Androsace occidentalis*, Fountain (I, IU, B). *Lysimachia hybrida*, Fountain (I). *L. lanceolata*, Fountain (I). *L. qualriflora*, Fountain (I, IU, B). *Dodecatheon meadia*, Wells (I). *Fraxinus nigra*, Parke (I). *F. pennsylvanica* var. *subintegerrima*, Fountain (I). *Gentiana andrewsii*, Fountain (I), Marion (B). *Frasera (Swertia) caroliniensis*, Fayette (I). *Apocynum androsaemifolium*, Fountain (I). *A. cannabinum*, Fountain (I). *A. medium*, Fayette (I), Fountain (I).

Asclepias amplexicaulis, Fountain (I). *A. purpurascens*, Fountain (I). *Cuscuta campestris*, Fountain (I). *C. cephalanthi*, Fountain (I). *C. polygonorum*, Fountain (I). *Convolvulus arvensis*, Fountain (I). *C. sepium*, Fountain (I). *Ipomoea lacunosa*, Parke (I). *I. pandurata*, Morgan (IU). *Phlox pilosa*, Fountain (I). *Cynoglossum officinale*, Fayette (I). *Lithospermum arvense*, Clark (I). *L. croceum*, Fountain (I). *L. latifolium*, Fountain (I, IU, B). *Echium vulgare*, Hamilton (I), Ripley (B). *Verbena canadensis*, Fountain (I). *Isanthus brachiatus*, Fountain (I). *Scutellaria galericulata*, Fountain (I, IU). *Prunella vulgaris*, Rush

(I). *Physostegia speciosa (P. virginiana* var. *s.)*, Fountain (I), Parke (I, B). *Dracocephalum parviflorum*, Fountain (I, B). *Lamium amplexicaule*, Fountain (I). *L. purpureum*, Fountain (I, IU). *Leonurus cardiaca*, Parke (I). *Salvia lyrata*, Martin (I, B). *S. reflexa*, Wayne (I, B). *Monarda didyma*, Morgan (IU). *M. fistulosa* var. *mollis*, Brown (IU). *Hedeoma hispida*, Fountain (I). *Melissa officinalis*, Morgan (IU). *Pycnanthemum flexuosum*, Fountain (I, B). *P. virginianum*, Brown (IU), Monroe (IU). *Lycopus rubellus*, Fountain (I), Parke (I). *L. virginicus*, Fountain (I). *Mentha spicata*, Fountain (I). *Nicandra physalodes*, Warren (I). *Lycium halimifolium*, Fountain (I). *Physalis pubescens*, Fountain (I). *P. subglabrata*, Starke (IU). *Solanum rostratum*, Lake (I). *Linaria minor (Chaenorrhinum minus)*, Clark I, Fountain (I, IU). *L. vulgaris*, Fountain (I). *Collinsia verna*, Fountain (I). *Penstemon calycosus*, Parke (I, IU). *Gratiola neglecta*, Fountain (I, IU, B). *G. virginiana*, Fountain (I). *Lindernia dubia*, Fountain (I). *Veronica connata*, Fayette (I), Fountain (I). *V. persica*, Fountain (I, IU, B). *V. serpyllifolia*, Lake (I). *Veronicastrum virginicum*, Fountain (I, B). *Castilleja coccinea*, Fountain (I, IU, B). *Epifagus virginiana*, Fountain (I), Tippecanoe (I). *Ruellia humilis*, Fountain (I), Parke (I). *Plantago virginica*, Fayette (I), Fountain (I). *Houstonia purpurea*, Fayette (I). *Cephalanthus occidentalis*, Rush (I). *Galium pilosum*, Fountain (I). *G. tinctorium*, Fountain (I). *Viburnum lentago*, Fountain (I), Parke (I). *Triosteum aurantiacum*, Fountain (I). *Symphoricarpos orbiculatus*, Fountain (I, B). *Echinocystis lobata*, Fountain (I). *Citrullus vulgaris*, Fountain (I), Porter (I). *Campanula aparinoides*, Tippecanoe (I). *Specularia perfoliata*, Fayette (I). *Lobelia cardinalis*, Fountain (I). *L. siphilitica*, Fayette (I).

Vernonia missurica, Fountain (I). *Eupatorium altissimum*, Parke (I). *E. purpureum*, Fountain (I). *E. sessilifolium*, Fountain (I). *Liatris spicata*, Fountain (I). *Solidago bicolor*, Fountain (I). *S. patula*, Fountain (I). *S. riddellii*, Fountain (I). *S. rigida*, Fountain (I). *S. speciosa*, Fountain (I). *Boltonia asteroides* (incl. *B. latisquama*), Parke (I). *Aster furcatus*, Fountain (I). *A. patens*, Parke (I). *A. praealtus*, Fountain (I). *A. sagittifolius*, Parke (I). *A. s.* var. *drummondii*, Fountain (I). *A. simplex*, Fountain (I). *Antennaria neglecta*, Fountain (I). *Gnaphalium purpureum*, Fayette (I). *Silphium integrifolium*, Fountain (I). *S. laciniatum*, Fountain (I). *S. terebinthinaceum*, Fountain (I). *Xanthium pennsylvanicum*, Fountain (I). *Rudbeckia subtomentosa*, Fountain (I, IU). *Ratibida pinnata*, Fountain (I). *Helianthus annuus*, Fountain (I). *H. grosseserratus*, Fountain (I). *H. hirsutus*, Fountain (I), Parke (I). *Verbesina (Actinomeris) alternifolia*, Rush (I). *Galinsoga ciliata*, Fountain (I). *Helenium tenuifolium*, Fountain (I). *Coreopsis tripteris*, Fountain (I). *Anthemis cotula*, Fountain (I). *Matricaria matricarioides*, Fountain (I). *Chrysanthemum leucanthemum*, Fayette (I). *Tanacetum vulgare*, Fountain (I). *Artemisia annua*, Rush (I). **A. vulgaris** L. Gray Man. 8 ed., p. 1522. Ill. Flora (1952) v. 3, p. 390. Floyd (I). Collected by Harry E. Ahles and Franklin B. Buser. *Carduus nutans*, Fountain (I). *Cirsium arvense*, Fountain (I). *C. muticum*, Fountain (I). *Onopordum acanthium*, Clark (I). *Cichorium intybus*, Fountain (I). *Krigia*

biflora, Fountain (I). *Tragopogon pratensis*, Fayette (I), Fountain (I). *Sonchus arvensis*, Fountain (I). *S. oleraceus*, Fountain (I). *Lactuca biennis*, Parke (I). *L. saligna*, Boone (I), Fountain (I, IU, B), Hancock (I), Hendricks (I), Montgomery (I), Parke (I), Rush (I), Warren (I). *Prenanthes alba*, Fountain (I). *P. crepidinea*, Fountain (I).

Deletions

Carex comosa, drop Parke County. *Habenaria flava*, drop Parke County.

Note: The deaths of Dr. Ray C. Friesner and Dr. C. C. Deam during the past year, and leave of absence of Dr. T. G. Yuncker for work on Pacific islands left the state flora report without supervision. The chairman of the Taxonomy Section, Mr. Frank Buser, assumed the duties encumbent on an annual plant distribution record. The above report is credited to him with sincere thanks.

Indiana's Old Growth Forests

DANIEL DENUYL, Purdue University

There is very little recorded information about the original composition of Indiana forests before the white settlers came to the area. The notes and records of the early explorers are available but most of them deal with the region and not specifically with the State of Indiana as it is now defined. From these early accounts of the region it is apparent that a hardwood forest was present. According to Charles C. Deam, who had made a very thorough study of all the botanical records of the early explorers and botanists, common names of trees referred to by these early explorers, such as locust trees, could indicate either honey locust or black locust. Individual species of oak were not specifically recorded but grouped together. White oak was a term used for most of the species that belong to the white oak group as they are classified today. Consequently even those early records that contained accounts of the flora of Indiana can be regarded as being generally descriptive. Since the early travel routes of the explorers and early settlers were the water routes, many of them must have recorded the species which they observed along these water courses. Those species such as sycamore which could be easily identified, were recorded while those not so distinguishable were grouped. Probably the white oaks referred to were those that grew along the water courses such as swamp white oak. It appears that the early accounts prior to about 1800 were very general descriptions of the region and from most of them the composition of the forest in a specific locality cannot be ascertained.

Part of the early agricultural history of Indiana has been summarized by Latta (1). From this summary, it is evident that when the first settlers came into Indiana much of the land was covered with timber. Descriptions of the stands by the early writers can be summarized by stating that some of the forests were dense; some very dense with an understory of shrubs and vines; some parklike with large sized trees predominant; but every account indicates that the forests were predominately hardwoods. There are some records of pine being present, virginia pine in southern Indiana and white pine in the extreme northern part of the state. Cypress of the swamps in southwest Indiana and tamarack of the swamps in northern Indiana were also reported. Latta states that "the first white settlers found many large clearings in the forest in which crops were being grown by the Indian farmers. Some of these tracts had been abandoned, doubtless for more fertile areas or because of the removal of the tribe to other parts. . . . Whenever necessary, partial clearings were made in the forest. The trees were deadened by bruising the bark with stone axes and by scorching the bases of girdled trees." Apparently the Indians must have done considerable forest land clearing in some sections of Indiana in order to grow crops to feed their people. Their many centuries of occupation must have had some influence on forest composition.

As the early settlers came into Indiana, the Indian practice of clearing away the forest was copied. The art of making maple sugar, commonly practiced by the Indians, was soon adopted by the white settlers. Thomas

Ashe (2) (1806) in his travels in America states, "In the spring of the year, sugar camps extended through the whole country; and the persons employed give the trees such great and unnecessary wounds that their whole virtue runs out and they perish perhaps in a season. . . . Persons of better regulated minds, tap the trees with an auger, insert a cane, draw off the liquor, and then stop up the flowing and the wound, by which means trees recover their vigor and afford fresh supplies in three to twelve years." While he does not specifically refer to Indiana in his travel account, the practice of making maple sugar was followed by both Indians and white settlers throughout the territory.

Although the first white men settled in Indiana in 1720, the era of active settlement occurred during the period of 1810-1870. In 1785, Congress authorized a systematic survey of the land and large tracts were acquired by colonization companies and wealthy private individuals. Land speculation was common but this did not discourage the settlers from coming to Indiana. By 1850, every county in the State had some settlers. The early settlers first established themselves along the river courses and along the Indian trails because they were the means of travel. After the completion of the canals, the "National Road," wagon roads, toll roads and the building of many railroads, settlement took place at a very rapid rate. The settlement of the interior of Indiana proceeded gradually from south to north. According to Latta, timberlands were first occupied. He records the following, "Notwithstanding the Herculean task of clearing the forest, the early settlers chose the higher timberlands. The reasons for this choice were: 1. Their previous experience. They were largely backwoodsmen with whom felling trees was an accomplished art. 2. The timber indicated the type and fertility of the soil, furnished material for fuel, building and fencing, and afforded shelter and food for both game and domesticated animals. 3. The prairie was thought unsuitable for settlement because of lack of wood and drinking water and its productiveness was not understood. 4. The treeless marshes and low-lying, rich, swamp land required immediate, extensive and expensive drainage for which the settlers had neither adequate knowledge, necessary funds, nor suitable materials. 5. After the deadening of the trees by the girdling of the trunks and the clearing out of the underbrush, the growing of crops, which was a prime necessity, could go on simultaneously with the gradual removal of the heavy timber."

The early pioneer used some timber for building his cabin, his barns and fences. There was little incentive for him to do other than dispose of the trees that he cut because until the advent of steam power and the sawmill, he had no market for his surplus timber. With the advent of the sawmill about 1860, there began extensive forest land clearing operations. With the development of farms, villages, towns, and cities, more hardwood timber was cut and used. The use of wood products increased as the production of agricultural products increased. Demands for wood to make all kinds of agricultural implements, wagons, barrels, boxes, and a host of other products caused the forests to be rapidly cut. Railroads, mines, factories, and many other new industries took large amounts of wood. During the period following the Civil War, thousands of saw-

mills operated in Indiana. Most of Indiana's forests were cut during the period of 1870-1910 and a large acreage of forest land was converted to agricultural crop use.

With the advent of the sawmill and with a large supply of merchantable timber, markets for hardwood timber increased. The development of the transportation system, especially the building and early operation of the railroads, required large amounts of timber. The railroads used large quantities of fuelwood prior to the use of coal. They were also the means by which the hardwood forest products were transported to markets. Fuelwood demands for home and industry, ties for both steam and electric railroads, and ties and props for the mining industry took out of the woods many of the smaller sized trees. Generally the oaks were the preferred species. The wagon stock industry, the basket factories, the furniture industry and numerous other wood using industries took only the highest quality timber.

Along with the removal of the forests and the clearing of land for agricultural crop use, timber was also cut from the forests which were later to be cleared or left in timber. These selective cuts consisted of the removal of the high quality black walnut, tulip poplar, black cherry and white oak. These selective cuts were followed by much heavier ones which usually removed all of the merchantable timber. These residual stands consisted of cull trees, small sized trees and species which were considered the least desirable for home or market use. Since many of these cut over forests were to be eventually converted to pasture or cropland, domestic livestock used them for pasture which helped to keep out the underbrush and natural regeneration of trees. Fire was commonly used to destroy the cut over forests.

One can conclude from this summary of Indiana's agricultural and industrial development during its settlement that the hardwood forest played an important part. The products that these old growth forests did produce have been recorded in the annals of Indiana's lumber production. According to Steer (3), "The earliest record of lumber production in the United States is contained in the census of 1809. With the exception of 1829, the record has been continued in each subsequent decennial census and annually since 1904." Prior to 1869 records were not separated by States but only the total hardwood lumber production was reported.

A record of hardwood lumber production in the United States and a summary of Indiana's hardwood lumber production are shown in Table 1. These figures show that the peak of the United States hardwood lumber production occurred in 1906 while the peak of Indiana's hardwood production occurred in 1899, when over one billion feet were cut. Indiana's percentage of the total cut has declined from 18 percent in 1869 to 2 percent in 1915. The present cut is still about 2 percent of the total.

It is apparent from the lumber production figures given in Table 1 that when the settlers first came into Indiana, they found a hardwood forest. The early production records show oak comprising approximately 80 percent of the total hardwood production in Indiana during the period 1869 to 1899 inclusive. Considering the merchantability and utilization standards of this early period there must have been many oak trees over

24 inches in diameter present in order to have production of oak lumber in the amounts reported by the sawmills. The records of lumber cut are very conservative because some operating sawmills did not report their cut. Even today the census figures on lumber cut do not include all of the operating sawmills.

The estimated total cut of hardwood sawtimber during the period of 1869 to 1903 inclusive was approximately 30 billion board feet. This means an average yearly cut of about 800 million board feet of which three-fourths were listed as oak. Considering the productive capacity of the forest lands of Indiana and the total acreage of forests from which the hardwood lumber has come, these old growth stands must have contained volumes ranging from 25 to 50 thousand board feet per acre. Then with the record of cut being such a high percentage of oak, it is easy to conceive that these old growth forests were predominately oak with numerous hardwood associates.

Since the record of species cut was incomplete until 1904, it is probable that beech was included with other species prior to 1904. The records do show the volume of maple cut and its percentage of the total cut varied from 1 to 7 percent. During the period of 1869 to 1899 inclusive, tulip poplar lumber production was two to three times that of maple.

The record of lumber production shown in Table 2 illustrates the continuing importance of oak and the increasing volume of beech that was cut during the period 1904-1915 inclusive. The total production for this period shows oak comprising 45% of the total cut, beech 13%, maple 8%, elm 7%, yellow poplar 5% and the other six species the remaining 22%.

Considering the entire record of Indiana's part in the hardwood lumber production, it is estimated that since cutting began approximately 50 billion board feet of hardwood timber have been cut from Indiana's forests. Of this total reported cut nearly two-thirds of the volume was oak. While beech and maple do enter into the production picture, their total contribution to Indiana's lumber production is comparatively small. These figures would indicate that beech and maple constituted part of the old growth forests but the "beech-maple" association must have occupied a minor position or must have been very much restricted in area.

The lumber production records for Indiana have their counterpart in the records available for Ohio, Illinois and Kentucky. In these states oak lumber production was similar to that of Indiana and the other hardwood species occupied similar positions in the lumber production records.

So it is probable that when the early ecologists came into Indiana and our neighboring states they did see residual stands in which beech and maple could easily have been prominent. The lumber production records clearly indicate that the oaks were the favored trees to be cut and hence during the period of 1880 to 1910 one's observations would put beech and perhaps maple into the ecological picture.

As a forester, I would conclude from the lumber production records, from settlement history and from the composition of the forests that is revealed in the early records that Indiana's old growth forests were predominately oak.

TABLE 1

Hardwood Lumber Production in the United States

Year	Millions of Board Feet	Percent of Total Cut in Indiana	Number of Sawmills in Indiana that Reported Production
1809	56		
1819	81		
1829	148		
1839	329		
1849	1,317		
1859	2,227		
1869	3,503	18	
1879	4,791	18	
1889	7,014	12	1,324
†1899	8,706	12	1,159
1904	10,462	5	718
*1906	11,110	4	820
1910	10,471	4	1,044
1915	7,526	2	354

* Peak of production in United States.
† Peak of production in Indiana.

Hardwood Lumber Production in Indiana

Millions of Board Feet

Year	Oak	Maple	Beech	Yellow Poplar	Black Walnut	Red Gum	Others	Total
1869	415	30		78		2	105	630
1879	690	20		60		5	87	862
1889	690	25		70		10	83	878
1899	682	27		56	10	34	223	1,032
1905	294	16	31	18	9	12	1	381
1915	80	16	31	6	11	8	36	198
1925	65	29	20	5	16	2	41	178
1935	42	15	8	3	3	1	13	85
1945	64	13	17	5		3	44	146

TABLE 2

Indiana Hardwood Lumber Production

Millions of Board Feet

Year	Oak	Elm	Maple	Yellow Poplar	Hickory	Ash	Red Gum	Black Walnut	Sycamore	Basswood	Beech	Others	Total
1904 ...	294	40	36	31	29	26	22	8	8	5	—	61	560
1905 ...	176	25	16	18	15	13	13	9	—	7	31	58	382
1906 ...	221	35	29	25	22	20	21	13	—	8	31	21	446
1907 ...	226	38	30	28	24	19	22	10	11	8	79	9	504
1908 ...	164	26	32	20	21	20	19	8	10	9	70	12	411
1909 ...	228	40	44	29	23	23	24	8	11	14	99	12	555
1910 ...	174	26	32	20	22	20	13	5	8	9	84	9	422
1911 ...	147	20	30	18	16	19	12	10	7	7	64	8	358
1912 ...	166	27	33	18	19	22	14	6	8	7	70	9	399
1913 ...	151	21	29	13	13	15	11	10	3	6	55	6	333
1914 ...	132	22	29	11	10	11	9	5	4	5	52	8	298
1915 ...	80	15	16	6	7	11	8	11	3	4	31	6	198
Totals .	2159	335	356	237	221	219	188	103	73	89	666	219	4866

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Natural Selection of Tetraploids in a Mixed Colony of *Tripsacum dactyloides*

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A year ago, the author reported the occurrence and origin of twin and triplet embryos in the tetraploid races of *Tripsacum dactyloides* (1). The one colony of this species which has been found in Indiana is located in Spencer County near the town of Santa Claus and shows a frequency of polyembryony exceeding 50%. The 2n chromosome number of this race has been reported by Anderson (2) as 72 but recent cytological studies of more than one hundred plants indicate that other ploidy levels are also present.

For example, of a group of seedlings collected in May, 1951, 21 pairs of twins were separated and chromosome counts obtained from root tip cells. In 10 pairs, one plant had 72 chromosomes and one had 36; in 5 pairs—72, 72; in 1 paid—36, 36; 1 pair—108, 72; and in 4 pairs—72, ?. In many cases it is possible to guess correctly which plant of a pair will have a chromosome number other than 72, for such a plant is frequently smaller and weaker than its 72-chromosome twin (Fig. 1). Root tip rather than meiotic counts are utilized because of the several years required to bring many of these plants into flower.

In the case of twins which were not separated, over one-third of the pairs lost one member within the first few months. If neither twin died in the first year, both plants appeared to be capable of existence indefinitely. It was suspected that the 72-chromosome plants were the ones surviving. This proved to be true in all 7 surviving twins from which counts were obtained. Of 10 plants single when collected, all 10 had a 2n number of 72. This points to the conclusion that, although plants with chromosome numbers other than 72 are produced, competition or genetic factors are such that many of these fail to survive. If this is true of material given greenhouse care, it is likely to be more so in nature where conditions are less ideal.

Some plants with somatic chromosome numbers other than 72, however, do survive in nature past the seedling stage. In the Santa Claus material this has been inferred partly from triploid seedlings, the most reasonable explanation of their origin being a cross between a tetraploid and a diploid. I have obtained several triploids (2n-54) from this location which are difficult to distinguish morphologically from tetraploids. Triploids have also been synthesized in the greenhouse from 4n x 2n and 2n x 4n crosses.

The 2n numbers of 36, 54, 72 and 108 which occur in the Indiana material, have also been found in collections of plants from a number of places in Florida. In addition to these chromosome numbers, somatic counts of 45 and 90 have been obtained there. Certain regions of Florida such as the Everglades and Pinellas Peninsula have shown a great deal of this sort of variation. In at least one locality, triploids outnumber the tetraploids and are more vigorous in appearance. This variation occurs

Figure 1.
Upper left: Triplet seedlings.
Upper right: Twin seedlings, one pair with embryos of unequal size.
Lower: Twin plants: 2n=36 on left, 2n=72 on right.

in races previously assumed to be tetraploid, an assumption probably based on one or very few actual counts. It emphasizes the need of counting the chromosomes in more than one plant of an area before deciding on the number. This is especially true when dealing with species where polyploidy and apomixis are suspected or are known to occur as they do in this species.

Because a good method of obtaining well spread chromosomes is essential when dealing with chromosome numbers as high as exist in tripsacum, the technique I have used is summarized here. It was adapted from information obtained in large part from Dr. Beal Hyde who compiled it from various sources.

In order to obtain clean root tips, potbound plants are removed from the flower pots and suspended in a cheesecloth bag over a beaker containing water. The roots grow through the cheesecloth into the moist air and when they are of sufficient length, ½ inch tips are removed and placed for one hour in a saturated, aqueous solution of paradichlorobenzene. This tends to hold the dividing cells at metaphase. The roots are then fixed in 3:1 absolute alcohol-acetic acid and left in the fixative for several days. This length of time in a strong fixative may seem excessive, but grass roots require it. The roots may be transferred to 70% alcohol for temporary storage but it is preferable to smear them without storing. When ready to smear, the extreme tip of the root is placed in a 1:1 HCl-95% alcohol solution for 5-10 minutes which causes the cells to be separated more readily. The tip is transferred to Carnoy's fixative for 5-10 minutes which tends to harden the chromosomes. The root tip is then smeared in a drop of iron acetocarmine.

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An Unusual Keratinophilic Microorganism

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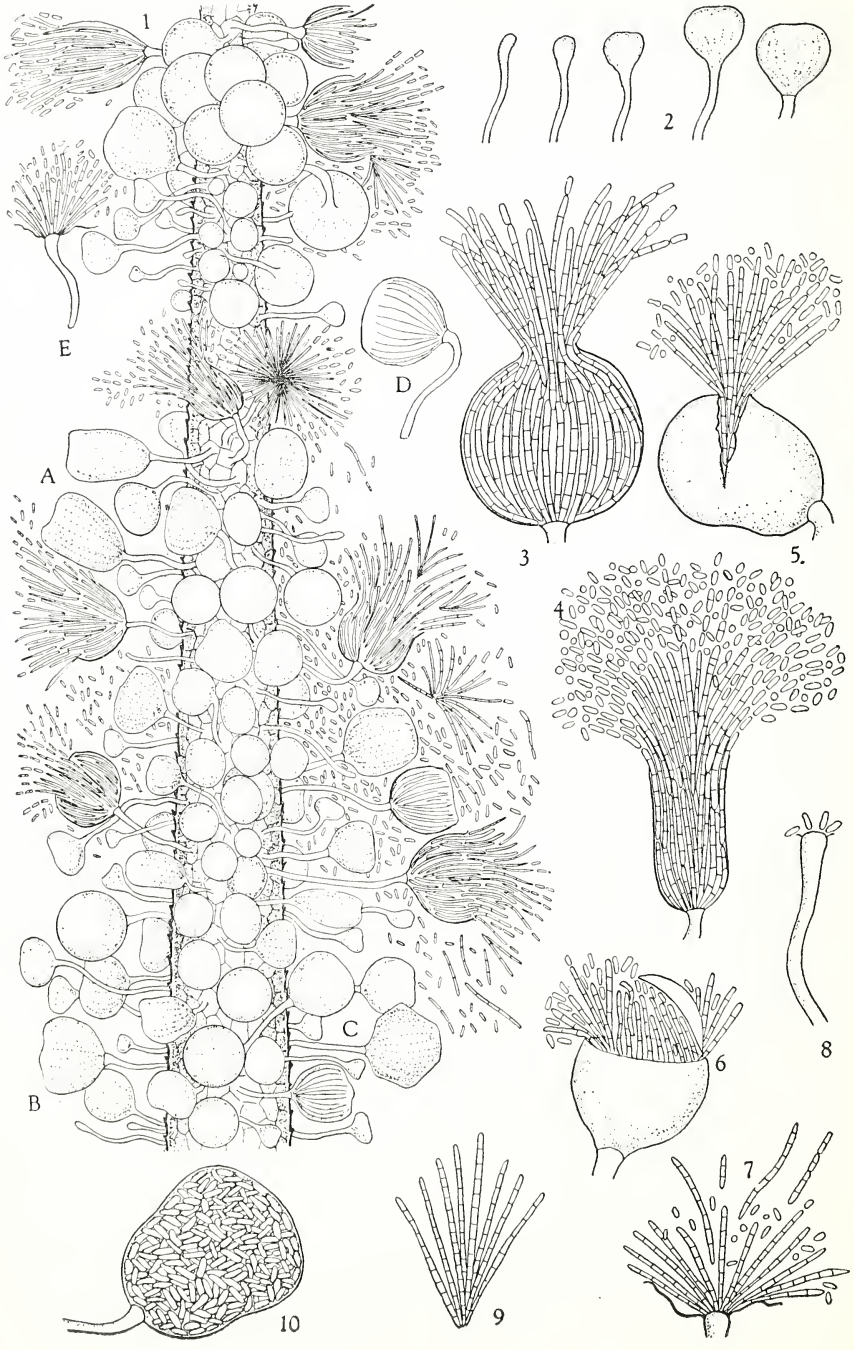
In the course of my studies on keratinophilic chytrids in the United States and Brazil an unusual microorganism was isolated from various keratinic substrata such as hair, snake skin, feathers, etc. This organism was discovered first in baited soil cultures from Van Cortlandt Park, New York City, in 1938 and later it was found in several cultures from various parts of the Amazon Valley in Brazil. Since then it has been found in soil from New Jersey, Virginia, Louisiana, Indiana and Iowa. Apparently, it is a widely distributed and common soil inhabitant. A description of this organism was given in connection with a paper on Brazilian chytrids which I presented at the annual meeting of the Mycological Society of America at St. Louis, Mo., in 1946 with the hope that microbiologists present might offer a clue to its identity and relationships. None were offered, and since that time a description of it has been presented at several meetings of bacteriologists. In the meantime, Couch's (1949, 1950) excellent studies on *Actinoplanes* have brought to light information on a group of organisms which combine what may be called fungal and bacterial characteristics, and the present organism appears to be related to this group. Accordingly, for the present it is being assigned provisionally to the family Actinoplanaceae. Studies are now being made on its cultural characteristics, nutrient requirements, life cycle and cytology for the purposes of determining its exact identity and relationships.

So far, human hair cut into short segments and bits of snake skin have proven to be the best bait for trapping this organism. When such substrata are floated on top of soil samples which have been flooded with animal charcoal water they usually become infected within two weeks if the organism is present in the soil. Fig 1 shows the extent to which a piece of human hair may become infected. Such fragments may disintegrate completely in the course of several weeks, which indicates that the organism is a fairly rapid decomposer of keratinophilic tissues.

This organism's most prominent characteristics are variously-shaped stalked sporangia which bear motile bacteria-like cells arranged in elongate filaments or rods as is shown in figs. 1 to 10. Its hyphae or stalks are quite slender and may vary from .8 to 2μ in diameter. The sporangia vary from spherical, 10-35μ, to urceolate, 8-20 x 12-30μ, oval, broadly obpyriform and angular in shape and have a hyaline, relatively thin wall. Under low magnifications they have a glistening appearance which makes them readily recognizable. As shown in fig. 2 they begin as knobs at the apex of projecting hyphae or stalks which may be 15 to 60μ in length. As they increase in size they assume the various shapes noted above and finally become delimited from the stalk by a cross septum. At the same time their content assumes a linear arrangement with lines oriented on the base of the sporangium and running to the apex as is clearly visible at A, B, C, and other places in fig. 1. The nature of this linear arrangement becomes quite clear as the sporangia mature and dehisce. It is the


1
2
E
D
A
3
5.
4
C
B
6
8
7
9
10

result of the development of long filaments or rods of bacteria-like cells from the contents of the sporangia.

Dehiscence of mature sporangia may be accelerated by placing them or the infected substrata in fresh animal charcoal water. Under such conditions they may dehisce within half an hour, and emit masses of individual cells or spores, filaments or rods of spores, or brush-like clumps of filaments. This is well-illustrated at various places in fig. 1. The sporangia may dehisce by deliquescence of the apex as in figs. 3 and 4, crack open as in fig. 5, or at times the apex may be lifted up like an operculum or lid as in fig. 6. Oftentimes, the entire apex may deliquesce and the spores and filaments are discharged in plume-like masses (fig. 4). Frequently most of the sporangial wall may disappear leaving only a remanent and a few filaments and spores attached to the stalk (figs. 7, 8). Fairly often the sporangia and stalks may break off from the substratum in mounting (figs. 1 D, 1 E), but these dehisce in the normal manner.

As noted earlier the cells or spores are arranged in long filaments or rods in the sporangia. During dehiscence the individual cells of a rod may separate and emerge singly, but usually entire rods or brush-like clumps of rods (fig. 10) may emerge or project out of the orifice of the sporangia as shown in figs. 3 and 5. The individuals at the projecting tip of the rods then separate in succession (figs. 4, 5) and swim away. Frequently, long filament of cells or bunches of them emerge and go swimming and whirling away in the surrounding medium (fig. 1) by the action of flagella on the individual cells. Eventually most if not all of the filaments or rods break up into individual cells, and the number of motile cells surrounding an infected piece of substrata may be so great that the water becomes markedly clouded. If the sporangia do not dehisce for a long time the individual cells of the filaments may separate and fill the sporangium with a seething mass of motile spores as shown in fig. 10. Occasionally, the lower part of a sporangium may be filled with separate motile cells while in the upper part the cells may still be connected in filaments.

The filaments or rods which emerge intact from the sporangium and can be measured accurately vary from 6 to 18μ in length, depending on

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Explanation of Figures

Fig. 1. Heavily infected segment of human hair showing immature, mature and dehiscing stalked sporangia.

Fig. 2. Stages in the development of a sporangium.

Fig. 3. Large globular dehiscing sporangium with filaments or rods of cells emerging at the apex.

Fig. 4. Large elongate sporangium whose entire apex has deliquesced. Filaments and individual cells emerging in a plume-like manner.

Fig. 5. Oval sporangium with a lateral tear or opening through which filaments are emerging.

Fig. 6. Small dehiscing sporangium with apical lid.

Figs. 7, 8. Remanents of sporangia and stalks with a few filaments and cells.

Fig. 9. Brush-like clump of filaments of cells.

Fig. 10. Undehisced sporangium filled with individual motile cells.

the number of cells of which they are composed, and are .8 to 1.5μ in diameter. The individual cells or spores are short rods, 2 to 3μ long by .8 to 1.5μ in diameter. Their movement or motility is typical of bacterial cells and quite unlike that of fungus zoaspores. So far the number lengths and position of the flagella have not been definitely determined.

So far no other type of fructification has been found in this organism, and it is not certain that it produces occasional conidia as in *Actinoplanes* or *Myceliochytrium* (Johnson, 1945). However, the evidence at hand suggests that it may be a member of the Actinoplanaceae and representative of a new genus.

Summary

An unusual saprophitic fungus- and bacterium-like organism was isolated from soil samples which had been baited with keratinophilic substrata such as human hair, snake skin, feather, etc.

So far as is known it is characterized primarily by spherical, oval, urceolate, elongate, and angular stalked sporangia which bear motile bacterium-like spores or cells arranged end to end in long filaments or rods.

Its identity and relationships are not certain yet, but it appears to be related to the Actinoplanaceae and is assigned provisionally to this family.

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The Present Status of Paleobotany in Indiana with Special Reference to the Fossils of Pennsylvanian Age[1]

Joseph M. Wood and James E. Canright, Indiana University

Paleontologists have long recognized the importance of the strategic position of the state of Indiana, situated as it is on the west side of the famous Cincinnati arch. Here fossiliferous rocks from the Ordovician through the Carboniferous are exposed for ready examination and collection. More specifically, Indiana lies on the Kankakee branch or arm of the Cincinnati arch. This arch began to rise sometime in the Ordovician and thereafter fluctuated around sea level so that sedimentary deposits were continually being added. In time, erosion levelled the surface so that now we have the layers exposed in such a way that if we go from a point halfway down the Indiana-Ohio border southwestward to the toe of the state, we pass over Ordovician, Silurian, Devonian, Mississippian, and Pennsylvanian formations in that order. All of the layers dip to the southwest at about 25 feet per mile. Thus, with this excellent cross section of time laid out before us so precisely, it is a relatively simple matter to examine the various horizons of the majority of Paleozoic strata.

Although the paleontologists have recognized the significance of Indiana's position on the arch, they have been concerned primarily with the collection and identification of the remains of marine faunas of the older Paleozoic rocks. The result has been that the extensive terrestrial floras of the Carboniferous, especially the Upper Carboniferous or Pennsylvanian, are but little known in Indiana, despite the considerable contribution of these ancient floras to this state's economy, namely, in the formation of our vast coal deposits.

The uses of faunal index fossils as correlative tools, as indicators of paleogeographical conditions, as indicators of past climates, and as supporting evidence for the laws of evolution are all well known. On the other hand, the application of plant fossils, especially macrofossils, to these same areas of study has received little or no attention in this state. A significant exception to the above is seen, however, in the palynological investigations of Dr. J. E. Potzger (9) and his students, which have yielded conclusive evidence concerning past climates and vegetation in Indiana.

The Annual Reports of the Geological Survey of Indiana from 1869 to 1900 carry sporadic accounts of the discovery and/or description of plant macrofossils by such men as L. Lesquereux, E. T. Cox, E. M. Kindle, D. D. Owen, David White and G. H. Ashley. Of the above, only Lesquereux and White were trained paleobotanists. Therefore, it is unfortunate that their descriptions of Indiana fossils were not based on their own field work, but instead, merely on material sent to them by Indiana Geological Survey field parties. After 1900 the reports relative to the discovery of plant fossils in Indiana are comparatively rare.

1. Published with the permission of the State Geologist.

By contrast, paleobotanical studies on Paleozoic floras in the surrounding states have been and are now being carried on by a relatively large group of workers. Lesquereux's fossil floras of Pennsylvania, of Illinois and of Kentucky were published between 1850 and 1883. Newberry's "Carboniferous Flora of Ohio" was published in 1873. David White described the fossil floras of West Virginia and Missouri between 1899 and 1907. C. A. Arnold, H. N. Andrews, and others are presently at work on the Paleozoic plants of Michigan, Iowa, and Kansas.

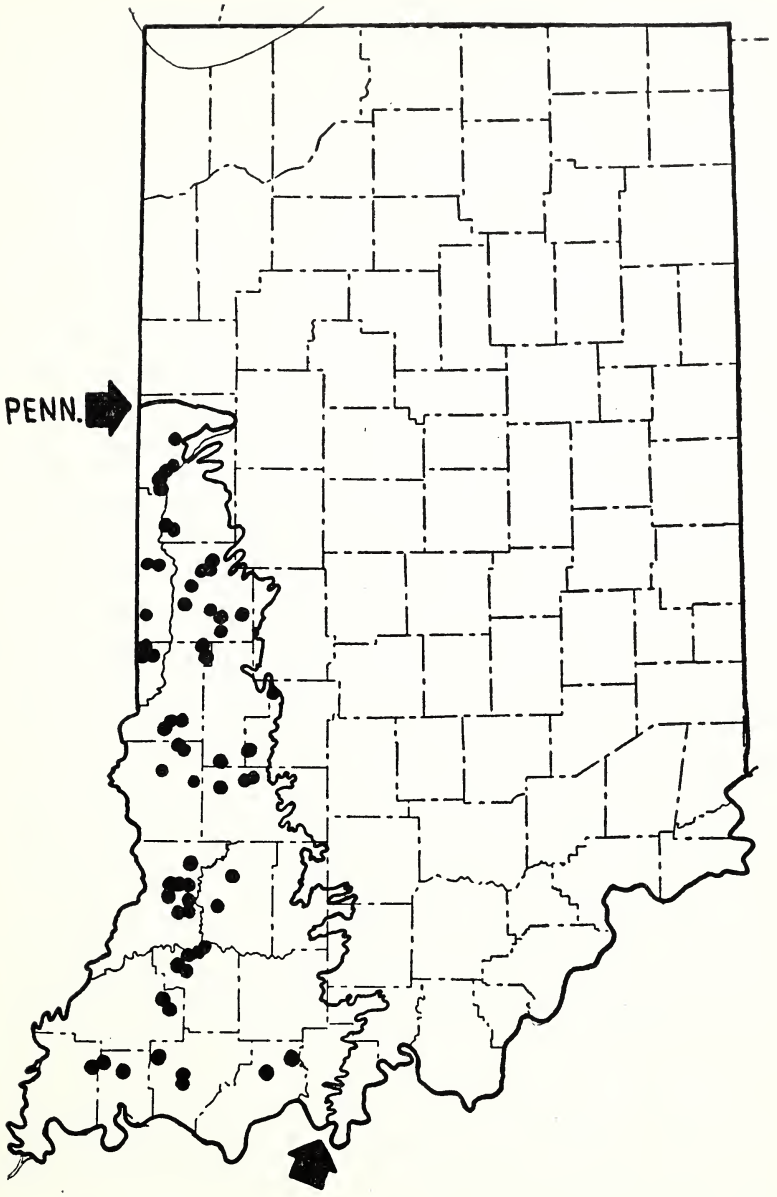
The main work in Indiana for the most part has been confined to the description of the floras as revealed in the casts, compressions, and/or coal balls of a few very localized areas. Thomas F. Jackson (5, 6) described some plants from the Lower Pennsylvanian rocks in the Bloomington quadrangle. R. W. Baxter (1) recently published an account of a new sphenopsid cone based on material found in coal balls that had been collected in the Pennsylvanian of Warrick County near Booneville. W. S. Benninghoff (2), a former student of W. C. Darrah's at Harvard, described a Pennsylvanian coal ball flora from species that he found at one mine near Petersburg in Pike County. Students of W. N. Stewart of the University of Illinois have published descriptions of psaroniaceous fern stipes from St. Wendell, Posey County, Indiana, coal balls (7, 8).

Work on a particular geological horizon of Indiana, such as the New Albany shales of Upper Devonian or Lower Mississippian age, by J. H. Hoskins and his co-workers (3, 4) provides an excellent exception to the general rule.

Nevertheless, the paucity of information on the Pennsylvanian of Indiana indicates that although several isolated floras have been described at this time, no one has assembled sufficient fossil material in order to ascertain the general overall picture of the Pennsylvanian flora of Indiana and its stratigraphic succession.

Last summer in preparation for the field work (under the auspices of the Indiana Geological Survey) the authors surveyed the literature pertaining to the plant fossils that had been reported in this state, especially those of the Pennsylvanian. These locations (144 in number) were transferred to a card file and also plotted on a sectional map of Indiana. Using these as guides, the authors set out, and in the course of four weeks, covered approximately 2,400 miles throughout the 23 counties of southern and western Indiana which are underlain by Pennsylvanian rocks. Needless to say, some of the slope mines and quarries which were glowingly described as good paleobotanical sites in the early pre-1900 reports are no longer of any value. Nevertheless, these reported sites often served as guides to other localities that did prove to be productive (Fig. 1).

The authors attempted, whenever possible, to collect the fossil plant material *in situ* in order that it might be of maximum stratigraphic value; in many cases this was feasible. However, the majority of our material was collected from the spoil banks of active and abandoned slope and strip mines. In some instances, excellently preserved plant fossils from newly-discarded roof shales of active shaft mines were collected. In the collection of materials from the spoil banks and the mine dump



Legend for Text Figure

Figure 1. Outline map showing the limit of Pennsylvanian outcrop in Indiana and sites of the authors' paleobotanical collections.

heaps, the fact that the profile of the strata was visible along the rims of the mines, and the knowledge of the coal that was being or had been mined in that particular area aided in placing the specimens in their proper stratigraphic position.

The discovery of fourteen previously unreported coal ball sites in eight counties, yielding approximately 500 coal balls of various sizes should be of especial interest to students of plant anatomy and phylogeny. The majority of the coal balls taken (and these are by no means all of the coal balls that are available at these sites) can be classed as *bona fide* coal balls, that is, with a matrix mainly calcareous or dolomitic in nature, and not pyritic. Those that have been sampled indicate that the structures which they contain are preserved in such a manner as to permit detailed study of their anatomical features.

A number of coal balls from the Wasson Mining Company's Big Creek Mine (now the Buckskin Mine) in Warrick County were collected in 1948 by members of the Indiana Geological Survey. Of these coal balls, the authors have found about 125 suitable for examination. These have been cut, polished, and etched with acid, after which nitrocellulose peels were prepared in the usual manner. These peels are now being studied; a more or less cursory examination indicates that the Pennsylvanian flora of this region very closely resembles that which Benninghoff in his 1943 report on the Pike County coal balls described as a "*Lepidodendron-Calamites*-Fern assemblage."

The coal balls collected by the authors during this last field season are now being processed in the same manner as were those that were previously mentioned. Preliminary studies of these have revealed that a number of seeds, such as *Lepidocarpon* spps. have been preserved, in addition to the many Coenopterid fructifications and stipes, *Calamites*, *Sphenophyllum*, and Lepidodendrid organs.

Several pyritized seeds, tentatively classified as *Trigonocarpus noeggerathi* (Lindley & Hutton) von Sternb. were found in an excellent state of preservation. The endocarp of one of these was cut and found to have been replaced in such a manner that anatomical studies may be made of the included structures.

A considerable number of cone compressions, mainly *Sigillariostrobus*, *Lepidostrobus*, *Paleostachya*, *Macrostachya*, *Volkmannia* and *Calamostachys* were found. Mr. G. K. Guennel of the Indiana Geological Survey has isolated spores from these samples so that these microfossils may be compared with presently-named spore materials found in our coal seams.

Impressions, casts and petrified woods were found in abundance in some areas, and these were often excellently preserved. Although the survey of this material is well under way, it would be premature at this time to make any statements as to the relative frequency of any of the genera that are included therein.

In summary, the following significant facts may be stated concerning the importance of continuing paleobotanical studies in Indiana: (1) with the material that is now at our disposal, a number of anatomical and morphological studies of phylogenetic importance can be made; naturally,

the collection of additional material will fill in conspicuous gaps in our present knowledge; (2) the possible use of plant macrofossils in the stratigraphic correlation of Indiana's coal beds is still in the process of evaluation, but seems to have considerable merit in several instances, particularly with Coals V and VII; (3) fossil plants in Indiana need description and cataloging for several reasons: a) to uncover more evidence concerning the Paleozoic floras and past climates of this region; b) for comparison with the better known Paleozoic floras of surrounding states as well as with those of the rest of the world; c) to determine whether a recognizable relationship exists between the floristic composition of Carboniferous climax types and the properties of the various coal seams in this state.

The wealth of the fossil plants that the authors were able to collect in Indiana in so short a time would suggest that literally "the surface has just been scratched." In this connection, the authors would like to quote a recent unequivocal statement made by one of this country's foremost paleobotanists, "Indiana is potentially one of the best localities in the world for the study of Pennsylvanian plant fossils."

In conclusion, therefore, the authors offer for your serious consideration the ancient Biblical quotation, ". . . seek and ye shall find . . ."

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Studies in Indiana Bryophytes XI

WINONA H. WELCH, DePauw University

Research grants from the Indiana Academy of Science through the American Association for the Advancement of Science and from the Graduate Council of DePauw University have aided the author in continuing these studies in Indiana bryophytes.

The writer has followed closely the treatment of Sphagnaceae by A. LeRoy Andrews in North American Flora 15:1-31. 1913, and O. E. Jennings, Manual of Mosses of Western Pennsylvania, pp. 20-42, 1951. The author acknowledges this aid with deep gratitude. To Dr. Andrews for his determination of the sphagnums collected in Indiana as well as for his criticisms and suggestions regarding this paper, and to Dr. Jennings and the American Midland Naturalist for the illustrations of the diagnostic characteristics, the writer is greatly indebted, and in this way expresses sincere thanks and appreciation.

SPHAGNACEAE. THE SPHAGNUM FAMILY

Plants deeply cespitose, large, erect, usually light grayish-green, sometimes yellowish, occasionally reddish, growing in younger portions as dying in the older; stem without rhizoids and a central strand, usually composed of an outer cortical sheath of parenchyma cells, an intermediate cylinder of prosenchymatous thick-walled cells (wood-cylinder), and a central area of parenchymatous cells (pith); branches in fascicles of two or more, the fascicles spirally arranged on the stem, near the apex densely crowded, usually some branches spreading at right angles to stem and others appressed-pendent; leaves in spiral arrangement, ecostate, composed of a layer of two kinds of cells, large, hyaline, somewhat elliptic or rhomboidal cells with walls usually perforated and spirally thickened (fibrillose) separated by narrow chlorophyllose cells uniting at the ends and forming a continuous cellular net; branch-leaves imbricate or nearly so, usually porose and fibrillose; stem-leaves distant, often lacking pores and spiral fibrils; monoicous or dioicous; seta none to very short; capsule borne upon an outgrowth of gametophyte (pseudopodium), globose, chestnut-colored to black; operculum small, convex; annulus and peristome lacking; calyptra irregularly lacerate; spores yellowish, tetrahedral with one large convex face and three smaller plane triangular ones, 18-45μ in longest diameter, disseminated by an explosive discharge from the capsule.

SPHAGNUM [Dill.] L.

Characters the same as those of the family.

Key to species of Sphagnum

1. Cortical cells of stem and branches reinforced by spiral fibril-bands. 2
   2. Chlorophyllose cells of branch-leaves short elliptic in cross section, centrally placed and entirely enclosed by the hyaline cells..... ..... *S. magellanicum.*

2. Chlorophyllose cells of branch-leaves usually triangular in cross section, with the base exposed on the inner (ventral) surface of the leaf 3
   3. Chlorophyllose cells of branch-leaves usually narrowly triangular or isosceles-triangular in cross section.....*S. palustre.*
   3. Chlorophyllose cells of branch-leaves very broadly triangular or equilateral-triangular in cross section.....4
      4. Branch-leaves with fringe- or comb-fibrils on walls of hyaline cells.....*S. imbricatum.*
      4. Branch-leaves without fringe- or comb-fibrils on walls of hyaline cells.....*S. imbricatum* var. *affine.*

1. Cortical cells of stem and branches without fibril-bands.....2
   2. Cortical cells of branches uniform, each with a pore at the upper end; chlorophyllose cells of branch-leaves in cross section enclosed on both surfaces.....*S. compactum*
   2. Cortical cells of branches of two kinds, or, if uniform, without pores; chlorophyllose cells of branch-leaves in cross section exposed on one or both surfaces.....3
      3. Chlorophyllose cells of branch-leaves in cross section free on outer (dorsal) surface of leaf; hyaline cells strongly convex on inner (ventral) surface.....4
         4. Cortical cells of stem small and scarcely different from inner cells, thick-walled; chlorophyllose cells of branch-leaves in cross section isosceles-triangular, the base of the triangle exposed on the outer (dorsal) surface of the leaf, the apex of the triangle reaching the inner (ventral) surface.....5
            5. Branch-leaves 1-2 mm. long, strongly undulate when dry .....*S. recurvum.*
            5. Branch-leaves about 1 mm. long, scarcely undulate when dry.....*S. recurvum* var. *tenue.*
         4. Cortical cells of stem moderately inflated, in one layer, different from inner cells, thin-walled; chlorophyllose cells of branch-leaves in cross section exposed equally on both surfaces or more broadly on the outer (dorsal) one.....*S. subsecundum.*
      3. Chlorophyllose cells of branch-leaves in cross section free on the inner (ventral) surface of leaf, and hyaline cells strongly convex on the outer (dorsal) surface.....4
         4. Stem-leaves fimbriate-lacerate in apical portion.....5
            5. Stem-leaves spoon-shaped, fimbriate-lacerate on upper margins and the apex.....*S. fimbriatum.*
            5. Stem-leaves tongue-shaped, fimbriate-lacerate only across the apex.....*S. Girgensohnii.*
         4. Stem-leaves toothed in the truncate apical portion..... *S. capillaceum.*

INDIANA SPECIES OF SPHAGNUM

S. capillaceum (Weiss) Schrank (Pl. A, as *S. acutifolium* Ehrh. var. *viride* Warnst.)[1] Plants generally short, 5-8 cm. high, compact, green, with a tinge of red; wood-cylinder mostly reddish; cortical cells of stem in 2-4 layers, thin-walled, without fibrils, the outer cells longer than wide, without pores; stem-leaves lingulate to triangular-ovate, 1-2 mm. long, very concave, usually two or more times as long as wide, border strong with cell walls strongly pitted, leaf apex usually involute pointed, toothed; hyaline cells of stem-leaves rhomboidal, 4-5:1 in apical part, with traces of fibrils; branches up to 1.5 cm. long, in fascicles of 3-5, 2 commonly spreading and recurved, others appressed-pendent, cortical cells of two kinds, in one layer, without fibrils, the retort-cells well differentiated with conspicuous neck and terminal pore; branch-leaves imbricate to slightly spreading, 1-2 mm. long, ovate-lanceolate to lanceolate, involute above to the toothed apex, bordered; hyaline cells of branch-leaves narrowly rhomboidal, 10-12:1 near base and shorter above, fibrillose, with small pores at cell-angles and sometimes lateral pores opposite the angle pores; chlorophyllose cells triangular to trapezoidal in cross section with the longer wall adjoining the hyaline cells, free on both surfaces but the hyaline cells projecting far beyond them both ventrally and dorsally; hyaline cells in cross section convex on the inner leaf surface and strongly so on the outer; capsule brown; spores yellow, 20-25μ in diameter, smooth to slightly granular-roughened. Specimens seen from Lake, Lawrence, Porter, and Putnam counties.

S. compactum DC. (Pl. A, as *S. compactum* DC. var. *squarrosum* Russ.) Plants usually short and compact, 4-8 cm. high, grayish green, glaucous green, or dirty white, especially when dry, sometimes grayish brown, occasionally green or nearly so; wood-cylinder usually brown, occasionally yellowish; cortical cells of stem in 2-3 layers, large, thin-walled, without fibrils, the outer cells quadrangular to pentagonal, sometimes longer than wide, without pores; stem-leaves 0.6-0.8 mm. long, concave, short lingulate to triangular-lingulate, cell walls pitted, especially in narrow marginal cells, leaf apex occasionally lacerate or slightly so; hyaline cells of stem leaves broadly rhomboidal without fibrils or pores; branches short, up to 1 cm. long, compactly arranged in close fascicles of 4-5, 2 stronger, spreading or ascending, rigid, others appressed-pendent, cortical cells in one layer, uniform, without fibrils, apex of each cell produced outwardly into a slight neck which ends in a pore; branch-leaves imbricate to strongly squarrose, large, 2-3 mm. long, ovate-hastate, margins involute, slightly denticulate, apex truncate, toothed; hyaline cells of branch-leaves rather broadly rhomboidal or irregularly hexagonal-rhomboidal, 6-8:1 near base, shorter above, fibrillose, on outer leaf surface with several large round pores irregularly scattered and also in cell-angles, usually 4-8 per cell, on inner leaf surface pores small oval and in cell-angles, commonly 3 in each cell; chlorophyllose cells elliptic in cross

1. In Jennings, Manual of Mosses, plate 5 illustrates both *Sphagnum acutifolium* and the variety *viride* Warnst. Jennings, on page 41, regards *S. capillaceum* as a synonym of *S. acutifolium*.

section, enclosed dorsally and ventrally by the moderately convex hyaline cells which are not at all to very slightly convex on outer leaf surface and more convex on inner surface of leaf; capsule brown; spores brownish yellow, 24-28μ in diameter, slightly granular-roughened. Specimens seen from Cass and Jasper counties.

S. fimbriatum Wils. (Pl. A.) Plants usually very slender and delicate, 4-5 cm. high, grayish green, occasionally yellowish, or yellowish brown; wood-cylinder green; cortical cells of stem in 1-3 layers, large with thin walls, without fibrils, outer cells quadrangular to irregularly pentagonal and hexagonal, generally longer than broad, with one large round pore in the upper end; stem-leaves broadly obovate-spatulate to short spatulate, 0.7-0.8 mm. long, often broader than long, concave, clasping the stem, apical portion fimbriate-lacerate on margins and apex; hyaline cells of stem-leaves rhomboidal, 2-3:1, without fibrils and pores; branches slender, up to 2.5 cm. long, usually in fascicles of 3-5, 2-3 spreading, others pendent, cortical cells of two kinds, in one layer, without fibrils, the retort-cells elongate and slender without distinct necks; branch-leaves imbricate, small, ovate-lanceolate to ovate, strongly concave, involute above, border entire, of 2-3 rows of narrow cells, leaf apex narrowly truncate and dentate; hyaline cells of branch-leaves narrowly rhomboidal, 8-12:1, with 4-6 fibrils, on the inner leaf surface 4-6 large rounded pores with diameter approximately equal to width of cell, on the outer leaf surface 5-8 smaller, elliptic pores; chlorophyllose cells trapezoidal in cross section, free on both surfaces, with slightly broader exposure on the inner leaf surface; walls of hyaline cells in cross section convex on both surfaces, more strongly so on the outer; capsule dark brown, briefly exserted; spores greenish yellow, 18-20μ in diameter according to Andrews and 25-30μ according to Jennings, smooth to slightly granular-roughened. Specimens seen from Elkhart county.

S. Girgensohnii Russow (Pl. A.) Plants commonly fairly robust, often very tall, 10-15 cm. high, usually green or grayish green, sometimes yellowish to brownish; wood-cylinder green, yellowish, or brownish; cortical cells of stem in 2-4 layers, large, thin-walled, without fibrils, the outer cells longer than wide, with a single large rounded pore in the upper end; stem-leaves 1-1.2 mm. long, short-lingulate, often as broad as long, slightly concave, broadened toward base where cell walls are pitted, the broad obtuse apex lacerate; hyaline cells of stem-leaves rhomboidal, 2-3:1 in apical part, without fibrils; branches 1.5-2.5 cm. long, in fascicles of 4-5, 2 spreading, others pendent and accumbent to stem, cortical cells of two kinds, in one layer, without fibrils, the retort-cells well developed with conspicuous necks; branch-leaves imbricate, rarely squarrose, 1-1.4 mm. long, lanceolate, lanceolate-ovate, or ovate, involute to involute tubular above, border entire, of 2-3 rows of narrow cells, leaf apex toothed, somewhat squarrose spreading; the median hyaline cells of branch-leaves ring-fibrillose and with many lateral pores between the fibrils; chlorophyllose cells commonly triangular to trapezoidal in cross section, with broader exposure on the inner leaf surface; hyaline cells in cross section slightly or not at all convex on inner surface of leaf, strongly convex on the outer, nearly enclosing the chlorophyllose cells; capsule

dark brown; spores brownish yellow, 20-25μ in diameter, strongly granular-roughened. Specimens seen from La Porte and Wells counties.

S. imbricatum Hornsch. var. *affine* (Ren. & Card.) Warnst. (Pl. A, as *S. affine* R. & C.) Plants low and compact to fairly robust, 4-8 cm. high, green or somewhat tinged with brown; wood-cylinder brown; cortical cells of stem in 3-4 layers, thin-walled, fibrillose, the outer cells irregularly quadrilateral to pentagonal, generally longer than wide, each with 4-10 irregularly rounded pores; stem-leaves lingulate to slightly spatulate, 1-1.8 mm. long, with hyaline border; hyaline cells of stem-leaves usually without fibrils and pores, sometimes divided; branches up to 1.5 cm. long, usually in fascicles of 5, 2 spreading, others appressed pendent, cortical cells in one layer, inner wall fibrillose, outer wall showing usually one pore; branch leaves usually imbricate, sometimes squarrose-spreading, ovate, not bordered, margin denticulate, apex cucullate; hyaline cells of branch-leaves 4-6:1, fibrillose, on inner leaf surface a few small ringed pores in corners of cells in apex and 2-12 large rounded pores in each cell, arranged usually in one row but sometimes in two rows, on outer leaf surface 4-12 elliptic pores in cells; chlorophyllose cells equilateral-triangular in cross section, widest on inner surface of leaf; hyaline cells in cross section very convex on outer leaf surface; basal hyaline cells of branch leaves without fringe- or comb-fibrils on the inner wall opposite the adjoining chlorophyllose cells; capsule globose, brown; spores brownish yellow, 20-25μ in diameter, smooth. Specimens seen from Lawrence and Porter counties.

S. magellanicum Brid. (Pl. B.) Plants compact to robust, up to 8-10 cm. high, bright green, grayish green, bluish green, tinged with brown, pink, red, or purple-red; wood-cylinder usually red, occasionally brown, walls of cells thick; cortical cells of stem in 3-5 layers, walls very thin, reinforced by weak fibril-bands, outer cells smallest and varying in shape and size, their pores rather large, round to laterally elongate, 1-2 in each cell; stem-leaves 1-2 mm. long, long lingulate to broadly lingulate spatulate, upper margins and broadly rounded apex fimbriate; hyaline cells of stem leaves non-fibrillose to fibrillose, porose on dorsal surface of leaf; branches usually short, up to 1 cm. long, occasionally up to 1.5 cm. in length, in fascicles of 4-5, 2 spreading, others appressed pendent, cortical cells in one layer, fibrillose, porose; branch-leaves imbricate to spreading, 1.5-2 mm. long, broadly ovate, very concave, cucullate, margins denticulate, especially near apex; hyaline cells of branch-leaves rhomboidal, 4-7:1, fibrillose with weak fibril bands, porose dorsally and ventrally, on outer surface of leaf 4-10 large elliptic pores per cell in angles of cells, on inner surface very few pores and in angles of apical and lateral cells of leaf; chlorophyllose cells central and elliptic in cross section, usually entirely enclosed by the hyaline cells which are scarcely convex on ventral surface of leaf and not convex to very slightly so on the dorsal surface; capsule considerably exserted, dark brown; spores brownish yellow to rust colored, 24-30μ in diameter, minutely papillose or finely punctulate. Specimens seen from Fulton, Kosciusko, Noble, and Porter counties.

S. palustre L. (Pl. B, as *S. palustre* and as *S. cymbifolium* Ehrh.) Plants low, compact to robust, usually 8-10 cm. high, sometimes up to 30

cm. in height, green, bluish green, yellowish green, at times tinged with brown; wood-cylinder brownish or yellowish; cortical cells of stem in 3-4 layers of inflated cells, innermost largest, outer cells rectangular, quadrilateral, or pentagonal, walls thin, fibrillose, with 1-4 irregularly rounded pores; stem-leaves up to 3 mm. long and 1.25 mm. wide, spatulate-lingulate, margin toothed, apex broadly rounded, slightly erose-fimbriate; lower hyaline cells of stem-leaves sometimes septate, neither fibrillose nor porose, the upper hyaline cells frequently as broad as long, fibrillose and porose; branches 1-2.5 cm. in length, in fascicles of 4-5, 2 spreading, others pendent and closely appressed to stem, cortical cells in one layer, inflated, rectangular, fibrillose, porose; branch leaves imbricate or spreading to squarrose, up to 3 mm. long, broadly ovate, very concave, margins involute, apex cucullate; hyaline cells of branch leaves rhomboidal, 3-5:1, fibrillose, on ventral surface of leaf porose with large elliptic to rounded pores, usually in cell-angles but occasionally in central portion of cell, more numerous in marginal cells where 2-8 per cell, dorsally 3-10 pores per cell, large round pores in ends of cells and small elliptic ringed ones in angles of cells; chlorophyllose cells narrowly isosceles-triangular in cross section with a short base exposed on ventral surface of leaf and almost even with ventral surface of hyaline cells, on dorsal surface hyaline cells very convex and projecting much beyond chlorophyllose cells; capsule considerably exserted, brown; spores yellow, 20-33μ in diameter, granular-roughened. Specimens seen from Allen, Delaware, Hamilton, Harrison, Jackson, Kosciusko, Lagrange, Marshall, Monroe, Noble, Porter, Steuben, and Tippecanoe counties.

S. recurvum Beauv. (Pl. B.)[2] Plants usually somewhat robust, up to 30 cm. high, green, greenish yellow, whitish yellow, or brownish; wood-clinder yellowish green; cortical cells of stem scarcely differentiated, composed of 3-4 layers of small to medium-sized thick-walled cells, outer cells elongate-quadrilateral, without fibrils and pores; stem-leaves 0.5-0.8 mm. long, sometimes up to 1 mm. in length, triangular, ovate-triangular, to triangular-lingulate, with very wide border of linear hyaline cells at base, the border narrowing upwards and extending almost to the mucronate, rounded, or truncate, sometimes erose-denticulate apex; hyaline cells of stem-leaves usually neither fibrillose nor porose; branches usually up to 1 cm. in length, occasionally up to 1.5 cm. long, commonly in fascicles of 4-5, 2 spreading, others appressed-pendent, cortical cells of branches in one layer, elongate-rectangular, perforate, non-fibrillose, retort cells with inconspicuous necks; branch-leaves imbricate, 1-2 mm. long, undulate when dry with apices recurved, when moist erect-appressed and not undulate, tapering to a narrowly obtuse apex with two to three teeth, narrowly lanceolate or lanceolate-ovate, involute in apical portion, border entire, composed of 2-4 rows of very narrow cells; hyaline cells of branch leaves narrowly linear-rhomboidal, in basal portion 10-12:1, in upper portion 6-7:1, fibrillose and porose, on the ventral surface of leaf usually with 4-7 large pores per cell in cell-angles, on the dorsal surface

2. In correspondence with Dr. Jennings regarding plate 3, *Sphagnum recurvum*, it has been learned that the upper group of leaf-cells is median dorsal (2 cd) and the lower is median ventral (2 cv).

PLATE A

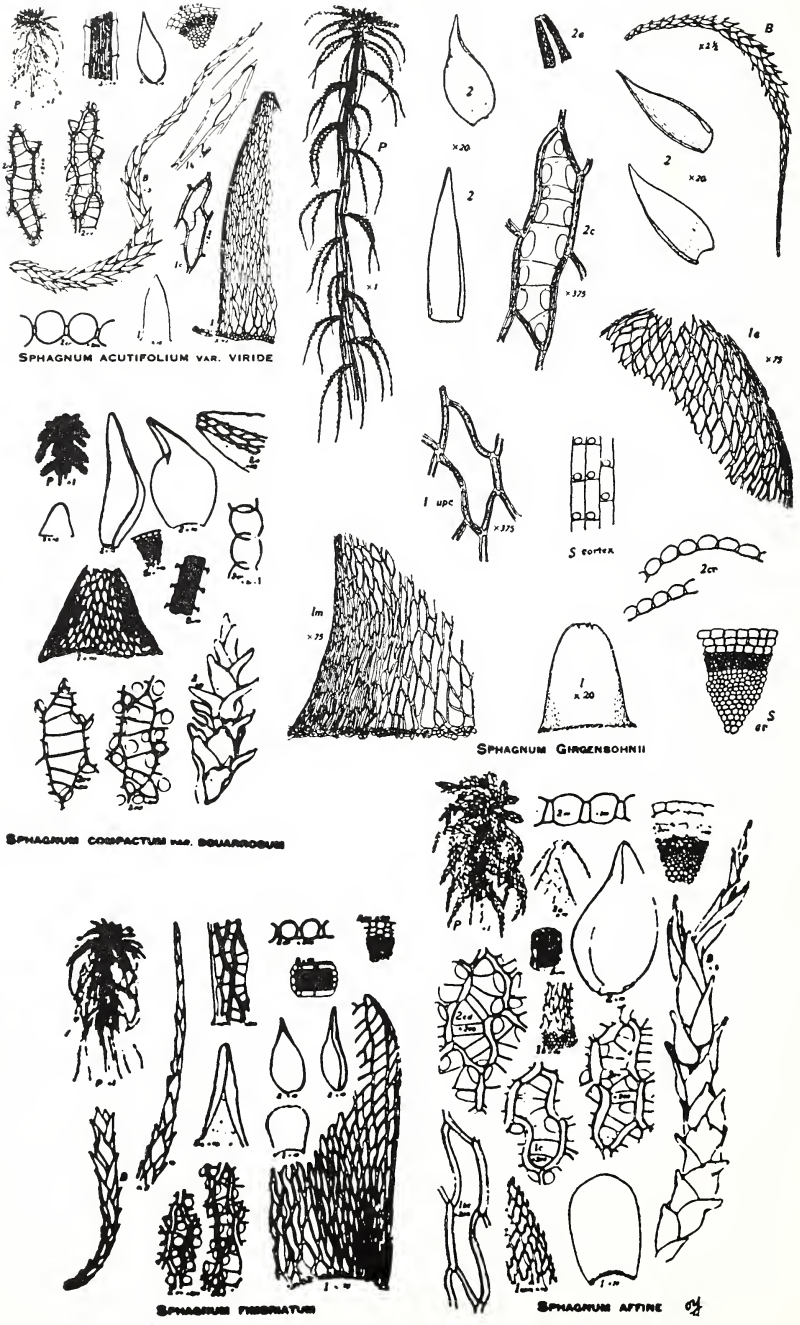
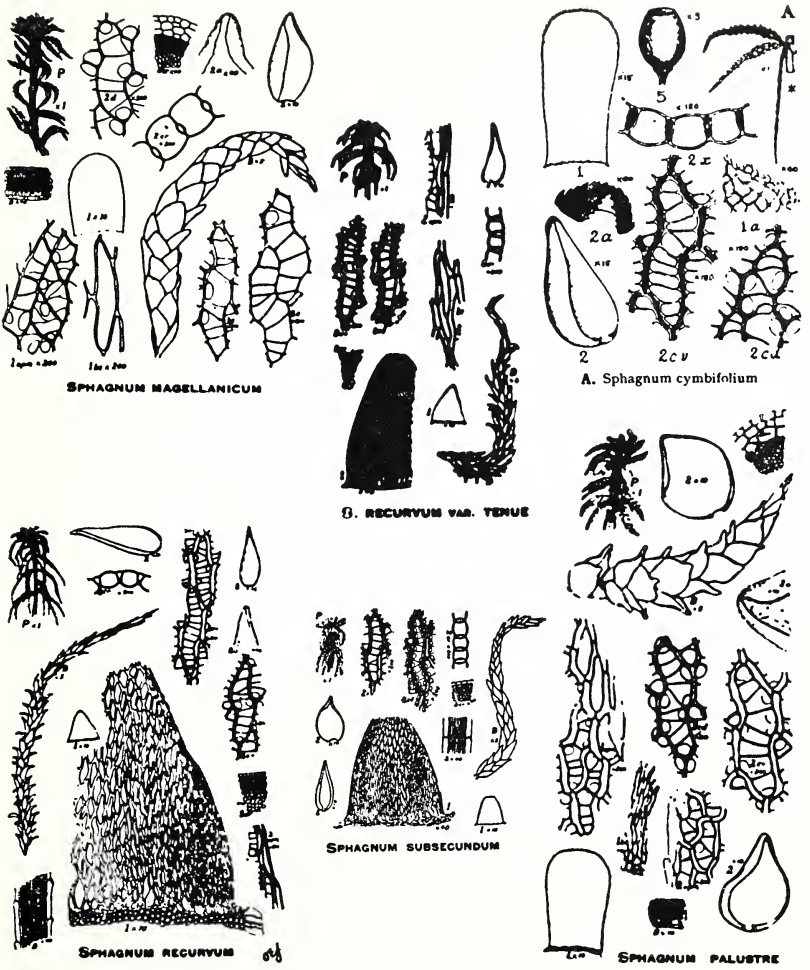

SPHAGNUM ACUTIFOLIUM VAR. VIRIDE
SPHAGNUM GIRGENSOHNII
SPHAGNUM COMPACTUM VAR. SQUARROSUM
SPHAGNUM FIMBRIATUM
SPHAGNUM AFFINE

PLATE B



Explanation of Plates A and B

All illustrations are reproductions of plates in O. E. Jennings, A Manual of the Mosses of Western Pennsylvania and Adjacent Regions, 1951, plates 1, 3, 5, 6, 7, and 9, with the exception of *Sphagnum cymbifolium,* which is from H. N. Dixon, The Student's Handbook of British Mosses, 1924, plate 1 A.

Explanation (from Jennings and Dixon) of letters and figures in the illustrations: a = apex; B = branch; b = base; bc = basal median; c = central or median; cr = cross section; d = dorsal; lm = lower margin; P = plant, habit sketch of plant or portion of plant; S = stem; upc = upper median; upm = upper margin; v = ventral; * = portion of plant; 1 = stem-leaf; 2 = branch-leaf; 5 = capsule.

usually 2-6 small end-pores per cell, occasionally a few ringed lateral pores; chlorophyllose cells usually triangular in cross section, with base of triangle exposed on dorsal leaf surface and the apex extending to the ventral surface or nearly so; hyaline cells in cross section scarcely convex on dorsal surface of leaf, slightly convex on the ventral surface; capsule brown; spores brownish yellow, 20-25μ in diameter, smoothish to granular-roughened. Specimens seen from Allen, Kosciusko, Lagrange, Marshall, Porter, and St. Joseph counties.

S. recurvum Beauv. var. *tenue* H. Klinggr. (Pl. B.) Plants of the variety shorter than in the species, 10-12 cm. high; branch-leaves loosely imbricate, about 1 mm. long, lanceolate, concave, dry leaves scarcely undulate, apices very slightly recurved, border hyaline, narrow, about the same width above as below, margin involute towards the narrowed somewhat truncate, slightly erose apex; upper hyaline cells of branch leaves with pores both in cell-angles and along the sides of the cells; otherwise similar to the species. Specimens seen from Kosciusko, Lagrange, and Marshall counties.

S. subsecundum Nees (Pl. B.) Plants small and delicate to robust, 5-20 cm. high, green, yellowish or brownish green, or purplish brown; wood-cylinder yellowish green, purplish brown, or brown; cortical cells of stem in 1 layer of moderately inflated cells, outer cells quadrilateral, walls thin, without fibrils or pores; stem-leaves small, 0.6-0.8 mm. long, triangular-lingulate, lingulate, or ovate, slightly auriculate, lower margin with broad hyaline border, the border narrowing above, the broadly rounded apex and the upper margin of leaves erose-fimbriate to fimbriate, apical portion of leaves concave and cucullate or nearly so; hyaline cells of stem-leaves narrowly rhomboidal, shorter and wider in apical portion of leaf, usually without fibrils, some with pores, a few cells septate; branches short, 6-8 mm. long, in fascicles of 2-6, 2-3 spreading, remainder pendent, cortical cells of branches in one layer, without fibrils, the retort cells with inconspicuous necks; branch-leaves when dry closely imbricate to subsecund, small, 1-1.5 mm. long, very concave, short elliptic, suborbicular, broadly ovate, or lanceolate, acuminate to narrowly truncate apex with 3-5 teeth, margins entire, involute, with narrow hyaline border of 2-3 rows of linear cells; hyaline cells of branch-leaves narrowly rhomboidal, 8-10:1 below to 4-5:1 above, fibrillose, on the ventral surface of the leaf non-porose to a few small round pores in angles of cells, on the dorsal surface with numerous small ringed round or elliptic pores along the sides of the cells, usually 10-20 per cell, sometimes more and sometimes less; chlorophyllose cells in cross-section narrowly barrel-shaped, relatively large in comparison with hyaline cells, free on both surfaces; the hyaline cells in cross section slightly convex on either surface, a little more convex on inner leaf surface than on the outer; capsule dark brown, briefly exserted; spores yellowish to brownish yellow, 25-28μ in diameter, finely papillose. Specimens seen from Cass, Harrison, Jefferson, Kosciusko, Porter, Spencer, and Starke counties.

CHEMISTRY

Chairman: JOHN H. BILLMAN, Indiana University

R. G. LARSON, Valparaiso University, was elected chairman for 1954.

ABSTRACTS

The Metalation of Alkyl Sulfones. WILLIAM E. TRUCE and KENNETH R. BUSER.—In view of the lack of information on the metalation of dialkyl sulfones, the action of organometallics on dialkyl sulfones is currently under investigation in this laboratory. This constitutes a preliminary report on our work in this field.

Dimethyl sulfone has been successfully metalated with both methylmagnesium iodide and ethylmagnesium bromide. The resultant methanesulfonylmethylmagnesium halide has been added to benzophenone and benzaldehyde. On hydrolysis, the adduct with benzophenone gave β-hydroxy-β, β-diphenylethyl methyl sulfone, while the adduct with benzaldehyde gave β-hydroxy-β-phenylethyl methyl sulfone.

For the metalation and the subsequent reaction of the metalated derivative, three different solvents, ethyl ether, benzene, and anisole, were tried. Of these, anisole gave the best results.

The superiority of anisole as a solvent is probably mainly due to the fact that both dimethyl sulfone and the metalated derivative appear to be more soluble in anisole than in either benzene or ether and also to the higher reaction temperature possible with anisole than with either of the other solvents.

Put S. A. in those demonstration lectures! ERNEST H. GHERKIN, Indiana University.—Our present efforts to increase the number of chemistry majors will fail unless we can hold the students beyond the general chemistry course.

The problem of arousing and nourishing a growing interest on the part of the student demands considerably more of the lecturer than a mechanical recitation of facts. Enthusiasm is the watch-word and after that come such traits as absolute fairness, a ready sense of humor and as good showmanship as can be developed.

Variety is not only the spice of life, it is life, and to this end the lecturer should develop a bag of tricks such as short inspirational quotes from literature, student participation, the old hair tonic formula, etc.

The preparation and properties of ethyl 4-methyl-2-quinolone-1-acetate. D. J. COOK and R. S. YUNGHANS.—The condensation of 4-methylcarbostyril with ethyl chloroacetate has been shown to give ethyl 4-methyl-2-quinolone-1-acetate by comparison of the above product with the known product which had been prepared from ethyl phenylglycine and diketene after ring closure of the substituted acetoacetanilide.

Chloracetamid when condensed with 4-methylcarbostyril follows the same method of addition while the addition of ethyl chlorocarbonate gives

an addition product which easily hydrolyzes to the original 4-methylcarbostyril.

The oxidation of 4-methylcarbostyril and ethyl 4-methyl-2-quinolone-1-acetate with selenium dioxide in diphenyl ether has been found to proceed in good yields. Ethyl 4-formyl-2-quinolone-1-acetate can be oxidized to the 4-carboxy derivative by oxidation with sodium dichromate and subsequent saponification of this acid-ester gives the diacid.

Some evidence is indicated that selenium dioxide oxidation of ethyl 4-methyl-2-quinolone-1-acetate might give along with the principal product, ethyl 4-formyl-2-quinolone-1-acetate, some ethyl 4-formyl-2-quinolone-1-glyoxylate.

Sulphuric acid. D. A. DAVENPORT, Purdue University.—Even a cursory examination of the widespread uses of sulphuric acid and oleum in organic chemistry indicates that in any one case sulphuric acid may be acting in one or more of a number of capacities. Proton availability, sulphur trioxide availability, and ionizing power seem to be particularly important. By using our knowledge of the inorganic chemistry of sulphuric acid solutions it is possible to account qualitatively, and at times semi-quantitatively, for its reaction with organic compounds. This is illustrated by reference to aromatic sulphonation, deuteration and desulphonation and also by the reaction of sulphuric acid and sulphur trioxide with ethylene-type double bonds.

Metallic Complexes in Liquid HF. ALAN F. CLIFFORD, Purdue University.—Evidence is presented for the existence in liquid HF of complexes of Co(II), Co(III), Ni(II), Cu(II), Zn(II), Hg(II) and Pb(II). In particular the system Ni(II)-CH_3CN is discussed and evidence presented for the existence of the ions $NiCH_3CN^{+2}$ and $Ni(CH_3CN)^{+2}_{1+x}$. The instability constant for the former was found to be 1.7×10^{-3}.

The prediction of the shapes of inorganic ions and molecules from simple electrostatics. ALAN W. SEARCY, Purdue University.—The shapes of ions and molecules are predicted to be the most symetrical arrangements possible for the pairs of valence electrons, whether bonding or nonbonding. The bond directions predicted agree in most cases with observation to within a few degrees. The significance of the good general agreement to chemical theory is discussed.

Pyrrolidine-copper complex ions. ALVIN W. MEIBOHM and LARRY P. SCHIEB, Valparaiso University.—Copper can be determined colorimetrically by use of pyrrolidine. The blue color is stable, reaches its maximum absorption at 600 mμ, obeys Beer's law and is independent of excess amine. An ammonium nitrate concentration of 2.0 M should be present to prevent precipitation of cupric hydroxide. The reagent is 1.3 times as sensitive as ammonia.

Ions with a pyrrolidine-copper ratio of 1:1 and 4:1 were found to be present in solution.

Some Comments on the *Q-e* Copolymerization Scheme[1]

T. C. Schwan, Valparaiso University
C. C. Price, University of Notre Dame

Introduction

The *Q-e* copolymerization scheme was developed by Alfrey and Price (1), to treat quantitatively the resonance and polarity factors which along with steric factors, of course, have been shown to be largely responsible for observed monomer behavior (2, 3). By relating the relative reactivity ratios to the Arrhenius equation for reaction rate, Alfrey and Price were able to calculate a series of relative values for the above resonance and polarity factors according to the following equations:

$$r_1 = \frac{Q_1}{Q_2} \cdot e^{-e_1(e_1-e_2)}$$

$$r_2 = \frac{Q_2}{Q_1} \cdot e^{-e_2(e_2-e_1)}$$

$$r_1 \, r_2 = e^{-(e_1-e_2)^2}$$

where r_1 and r_2 are the relative reactivity ratios, Q_1 and Q_2 are activation factors related to the resonance stabilization of the respective monomers, and e_1 and e_2 are electrical factors pertaining to the electron concentration at the double bond in the respective reacting monomers or monomer free radicals.

Since the above equations have only a quasitheoretical derivation, differences of opinion concerning the utility, accuracy, and validity of the *Q-e* scheme have arisen (4, 5, 6). Alfrey, Bohrer and Mark (4) have concluded that the values obtained for *Q* and *e* are only semiquantitative and that the real problem is the extent to which this scheme can be considered a quantitative method of correlation.

Q and *e* Values for Ethyl Vinyl Ether from Recorded Data

One facet of this problem was encountered in a recent investigation of the copolymerization properties of certain 1,2-disubstituted ethylenes (7). An attempt was made to calculate from data in the literature *Q* and *e* values for ethyl vinyl ether. There were found paired with ethyl vinyl ether five different monomers for which reactivity ratios had been recorded (8, 9, 10). However, each pair represented the extreme case in which one of the monomers, in this case ethyl vinyl ether, showed extreme reluctance to copolymerize. This reluctance to copolymerize results in a vanishingly small reactivity ratio for the reluctant monomer, and the ratio is usually and meaninglessly reported as zero. This was the case for ethyl vinyl ether. However, by using data from two different monomer

1. This paper was made possible largely by a grant-in-aid by Research Corporation, and is hereby gratefully acknowledged.

pairs in simultaneous equations, close agreement for the Q and e values was obtained from three of the five sets of data, but the other two gave widely divergent Q and e values. Since most of this recorded data was the result of single experiments, the divergent data was ignored. By this discriminatory use of data, Q and e for ethyl vinyl ether were found to be 0.01 and —0.7 respectively.

Q and e Values for Ethyl Vinyl Ether from Experimentally Obtained Data

An attempt was made to check this data experimentally by copolymerizing ethyl vinyl ether with styrene, acrylonitrile and ethyl fumarate. Reactivity ratios were calculated by the "intersection" method (11) which involves a graphic solution based on the following equation:

$$r_2 = \frac{M_1}{M_2}\left[\frac{m_2}{m_1}(1 + \frac{M_1}{M_2} r_1) - 1\right]$$

where M_1 and M_2 are the concentration of monomers in the original monomer mixture and m_1 and m_2 are the concentration of the respective monomers in the resulting copolymer. Since one monomer composition gives a single line on the plot, it does not afford a solution of the reactivity ratios. Several different concentrations of monomers are needed to give an area of intersection from which can be obtained values of r_1 and r_2 and a general idea of the size of the errors involved. The plots for the above copolymerizations are given in figures 1, 2 and 3.

Acrylonitrile was the only monomer to give a solution: $r_1 = 0.03 \pm .02$ and $r_2 = 0.7 \pm .02$. Using $r_1 = 0.03$ and $r_2 = 0.70$, for ethyl vinyl ether, $Q = 0.061$ and $e = -0.77$ which results are in excellent agreement with the above results calculated from the recorded data.

Styrene and ethyl fumarate gave no solution nor a single indication of an r_2 value. In fact, the plots indicate a negative r_1 value. The significance of this phenomenon has not been explained satisfactorily as yet. The widely divergent lines on the styrene-ethyl vinyl ether plot indicate a very low accuracy as might be expected from the very low concentration of ethyl vinyl ether found in the copolymer.

The ethyl fumarate-ethyl vinyl ether plot, however, indicates a certain degree of accuracy in that the two sets of lines are the results of two different series of copolymerization: one made near the beginning of the investigation and the other toward the end of the investigation. The same phenomenon of a possible negative r_1 value is exhibited here.

If in these last two copolymerizations, the r_2 values given by ethyl fumarate are used with the r_2 values obtained by the same monomer ratio of styrene with ethyl vinyl ether in simultaneous equations, the following values for Q and e for ethyl vinyl ether are obtained:

Mole Fraction Ethyl Vinyl Ether	r_2 Styrene	r'_2 Ethyl Fumarate	Q Ethyl Vinyl Ether	e Ethyl Vinyl Ether
0.2	40	1.2	0.02	–0.52
0.5	60	2.7	0.01	–0.33
0.8	130	9	0.005	–0.16

The most nearly horizontal lines on the plots give the least error in r_2. Therefore, the Q and e values obtained from these lines, which result from the lowest concentration of ethyl vinyl ether, should give the most accurate results. These results, $Q = 0.02$ and $e = -0.52$ are in good agreement with previously presented values (6).

While this last method is admittedly open to question, the agreement of results when the data in this rather extreme case is handled judiciously cannot help but add credibility to the accuracy and validity of the Q-e scheme.

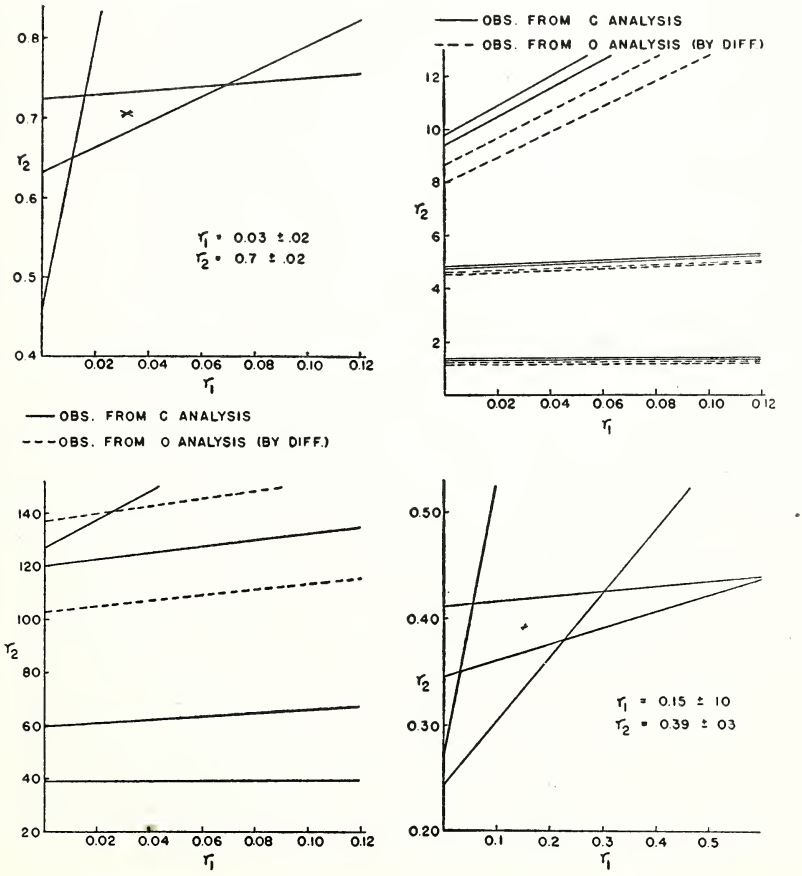


Fig. 1. (Upper left.) Copolymerization of ethyl vinyl ether (M_1) with acrylonitrile (M_2) indicating solution for the reactivity ratios.

Fig. 2. (Lower left.) Copolymerization of ethyl vinyl ether (M_1) with styrene (M_2) showing no solution for the reactivity ratios.

Fig. 3. (Upper right.) Copolymerization of ethyl vinyl ether (M_1) with ethyl fumarate (M_2) showing no solution for the reactivity ratios.

Fig. 4. (Lower right.) Copolymerization of crotonic acid (M_1) with vinyl acetate (M_2) (13) indicating solution for the reactivity ratios by the intersection method.

Recent Criticism of *Q-e* Scheme

A recent, damaging attack (12) on the basic validity of the scheme has resulted largely from the accumulation of certain contradictory data including Q and e values for crotonic acid. Reactivity ratios for the copolymerization of crotonic acid with vinyl acetate (13) were calculated by a curve-fitting method and were found to be $r_1 = 0.01$ and $r_2 = 0.3$ giving for crotonic acid $Q = 0.04$ and $e = 2.71$. Recalculation of the reactivity ratios by the intersection method gives the solution indicated in figure 4. Using $r_1 = 0.15$ and $r_2 = 0.39$, for crotonic acid, $Q = 0.053$ and $e = 1.43$ which results are in line with data for a large number of other monomers (6).

Obviously then, this attack on the basic validity of the *Q-e* scheme can be written off on the grounds of erroneous data or faulty computation.

Experimental

Monomers were purified by distillation through a 60 cm. glass helices packed column.

Mixtures of monomer pairs containing a total of 0.08 mole of monomer and 0.00016 mole of benzoyl peroxide were made up over a wide range of composition. The monomers were weighed to the nearest 0.5 mg. on an analytical balance in soft glass test tubes approximately 150 mm. by 18 mm. drawn out to a diameter of about 3 mm. about 40 mm. from the mouth of the test tube. Immediately after the final weighing, the tubes were placed in an ice bath, flushed with nitrogen for one minute and sealed. The tubes were placed in a constant temperature water bath maintained at 60° ± 0.2° C. When approximately ten per cent conversion had taken place as indicated by an increase in viscosity, the tubes were removed from the bath, cooled in an ice bath, opened and poured into 250 cc. of filtered methyl alcohol. Samples were prepared for analysis as follows. The acrylonitrile copolymer was dissolved in dimethyl formamide, filtered and slowly precipitated in methyl alcohol. The styrene copolymer was dissolved in benzene, filtered and reprecipitated in methyl alcohol. The ethyl fumarate copolymer, soluble in methyl alcohol, was precipitated in ligroin, redissolved in ether, filtered and reprecipitated in ligroin. All samples were reprecipitated at least twice and dried for at least 48 hours in a vacuum oven at 65°C and 30 mm. pressure. Analyses were performed by Microtech Laboratories, Skokie, Illinois.

Summary

Good agreement in judiciously treated recorded data and further experimental data for ethyl vinyl ether indicates even in this extreme case, the general accuracy of the *Q-e* scheme.

A recent attack on the basic validity of the *Q-e* scheme has been shown to be unsubstantiated.

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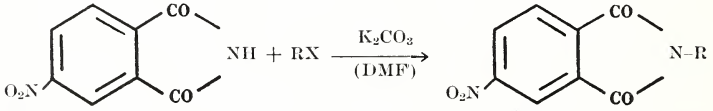
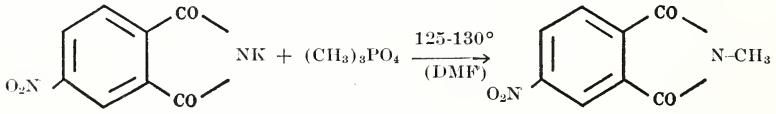
4-Nitrophthalimide III. Methylation with Trimethyl Phosphate and Hydroxymethylation with Formaldehyde[1]

JOHN H. BILLMAN and R. VINCENT CASH, Indiana University

In an earlier paper (2) we reported that 4-nitrophthalimide can be alkylated to give solid derivatives of alkyl halides and that these derivatives afford a satisfactory saponification equivalent. Dimethylformamide was employed as a reaction medium for these alkylations (1).

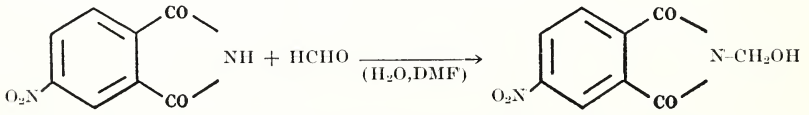


We now wish to describe two related reactions of 4-nitrophthalimide. Methyl phosphate in the presence of dimethylformamide can be used to methylate potassium 4-nitrophthalimide in good yield, giving a product identical with that obtainable from methyl iodide.



The high-boiling trimethyl phosphate is more convenient as a reagent than the low-boiling methyl iodide. This reaction shows similarity to that involving the use of alkyl esters of *p*-toluenesulfonic acid to introduce an alkyl group into phthalimide as reported by Sakellarios (6) and by Clemo and Walton (4).

The second reaction which we carried out involves the addition of formaldehyde to 4-nitrophthalimide to form N-dydroxymethyl-4-nitrophthalimide. This condensation is easily brought about by brief refluxing in a mixture of dimethylformamide and water.



The analogous condensation between phthalimide and formalin to yield N-hydroxymethylphthalimide has been recorded by Sachs (5) and by Buc (3).

Experimental

N-Methyl-4-nitrophthalimide. In a 250-ml. round-bottomed flask were placed 4.8 grams (0.021 mole) of potassium 4-nitrophthalimide, 2.0 grams (0.014 mole) of trimethyl phosphate, and 30 ml. of dimethylformamide. Under a reflux condenser bearing a drying tube, the mixture was heated

1. Contribution No. 623 from the Chemistry Departments of Indiana University and Teachers College of Connecticut.

at 125-130° for one and one-half hours. The cooled reaction mixture was poured into 100 ml. of cold water, using another 50 ml. of water to wash out the flask. The solid material which separated was collected, washed with water, and dried. This crude product weighed 4.5 grams and gave a melting point of 175.5-177.0°. After recrystallization from aqueous ethyl alcohol, the yield of colorless product was 3.5 grams (81.4% of theory). The melting point of this product, 177.5-178.0° was not depressed by mixing with an authentic sample of N-methyl-4-nitrophthalimide prepared from methyl iodide (2).

N-Hydroxymethyl-4-nitrophthalimide. A mixture of 19.2 grams (0.10 mole) of 4-nitrophthalimide, 8.3 ml. of 40% formalin (3.3 grams or 0.11 mole of formaldehyde), 75 ml. of water, and 25 ml. of dimethylformamide was heated under reflux until all the solid dissolved, and then five minutes longer. When the reaction mixture had been cooled overnight in a refrigerator, the crystalline material which formed was collected by filtration and washed with ice-cold water. After drying in air, the colorless product amounted to 18.2 grams. This was recrystallized from a mixture (4:1 by volume) of water and dimethylformamide, yielding 16.4 grams (74.0% of theory) of product of melting point, 156-157° cor.

Anal. Calc'd for $C_9H_6O_5N_2$: N, 12.60%. Found: N, 12.83%.

Summary

The methylation of potassium 4-nitrophthalimide by treatment with trimethyl phosphate in dimethylformamide is described as a novel and convenient preparation of N-methyl-4-nitrophthalimide. It is also shown that 4-nitrophthalimide can be condensed with formaldehyde to yield N-hydroxymethyl-4-nitrophthalimide.

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Identification of the Isomeric Phenylenediamines[1]

FRANK J. WELCHER, Indiana University, and JOHN A. BUEHLER, Anderson College

Reagents which are capable of reacting with organic compounds to form ring structures are frequently of great value in organic analysis (1). Many cations react with bifunctional organic compounds to form highly colored chelate complexes, provided the two functional groups are so located in the molecule as to permit the formation of stable 5- or 6-membered rings. As a rule these complexes are highly colored. Similarly, organic reagents may react with organic compounds to form ring structures which are colored, and thus permit the identification of the latter. These reactions possess the advantage in organic analysis that they reveal the presence of two reactive groups, and in addition they may also show their relative positions in the molecule. Further, steric configurations may be indicated.

A typical illustration of the use of inorganic cations for the identification of an organic compound is the characterization of anthranilic acid by means of various inorganic salts as proposed by Moses (5). When various classification tests have shown an unknown to be one of the three isomeric aminobenzoic acids, the o-isomer (anthranilic acid) is readily recognized by simply treating it with a solution of a cupric, nickel, or ferric salt. Only in anthanilic acid are the amino and carboxyl groups joined to the benzene ring in such a manner that a stable chelate ring can result. Unfortunately, the p- and m-isomers cannot be detected in this manner.

It is believed that by a careful selection of generally well-known reactions various isomeric compounds can be differentiated. In recent work carried out in this laboratory it became necessary to identify quickly the three isomeric phenylenediamines. A number of reactions were studied as a possible means of accomplishing this purpose. Those most suitable are:

(1) Acetylacetone.—Acetylacetone reacts in an acid solution with o-phenylenediamine to yield the intensely colored purple compound, 2,4-dimethyl-1,5-benzodiazepine, which contains a 7-member ring. (6, 7, 8, 9.) This reaction is very sensitive and is not given by the m- and p-isomers.

(2) The LaRosa Reaction.—When magnesium hydroxide is precipitated in the presence of the oxidation products of p-phenylenediamine, a violet-colored precipitate is formed (3). The o- and m-isomers do not give a similar test.

(3) The Lauth Reaction.—When p-aminodimethylaniline is treated in an acid solution with hydrogen sulfide and ferric chloride, the thiazine dye, methylene blue, is formed (4). p-Phenylenediamine reacts similarly to give a clear blue solution. The o- and

1. Contribution No. 622 from the Chemistry Department, Indiana University.

m-isomers do not yield a blue color, but the former gives a reddish brown color and the latter a pale yellow color.

If the above reactions are applied to a small crystal of the phenylenediamine or the dihydrochloride on a spot plate, or in a test tube, it is possible in a minute or two to determine the positions of the two amino groups. With the acetylacetone reaction, a purple color indicates the o-isomer, since the m- and p-isomers do not react. In the absence of any color, the compound is shown to be either the m- or p-isomer. Then by applying the Lauth reaction, the p-isomer is indicated by the formation of a beautiful blue color and the m-compound by a very pale yellow color. Actually the Lauth reaction can be used to differentiate all three isomers, since the o-isomer gives a reddish brown color, the m-isomer a pale yellow, and the p-isomer a blue color; but this series of reactions is not as satisfactory as the combination of the two tests, especially if the amines are not pure. The tests are summarized in the following chart:

Reaction	o-Phenylene-diamine	m-Phenylene-diamine	p-Phenylene-diamine
Acetylacetone	Purple Solution	Colorless Solution	Colorless Solution
LaRosa	Greenish-yellow Precipitate	Orange-yellow Precipitate	Deep violet Precipitate
Lauth	Brownish-red Solution	Pale yellow Solution	Deep-blue Solution

The above reactions may be used to detect small quantities of the amines when the latter are present as impurities. For example, less than 1 per cent of o-phenylenediamine as an impurity can be detected in samples of the m- or p-isomers by the acetylacetone reaction. Similarly, 1 per cent of p-phenylenediamine can be detected in the presence of the other isomers by using the Lauth reaction if blanks are run simultaneously. The pure blue of the p-isomer is not obtained when o- and m-phenylenediamine are present, but the colors obtained with pure samples of the latter are significantly changed in the presence of small amounts of p-phenylenediamine. Small quantities of the three amines can also be detected in the presence of inert impurities.

Experimental

Acetylacetone Test.—Place a few crystals of the diamine to be tested on a spot plate and add 0.2 ml. of distilled water, one drop of 6 N HCl, and 2 drops of a 1 per cent aqueous solution of acetylacetone.

o-Phenylenediamine gives a purple colored solution.

m- and p-Phenylenediamines do not give a color reaction.

LaRosa Test.—Place a few crystals of the diamine to be tested on a spot plate, and then add 0.2 ml. of distilled water, one drop 6 N HCl, one drop of a $FeCl_3$ solution which contains 0.25 mg. of $FeCl_3$ per ml., 3 drops

of 6 N KOH, and two drops of a magnesium nitrate solution that contains 100 mg. of magnesium ion per ml.

o-Phenylenediamine gives a pale greenish-yellow precipitate.

m-Phenylenediamine gives a pale yellow-orange precipitate.

p-Phenylenediamine gives a deep violet colored precipitate.

Lauth Test.—Place a few crystals of the diamine on a spot plate, and add 0.2 ml. of distilled water, one drop of 6 N HCl, 0.2 ml. of a saturated aqueous solution of hydrogen sulfide, and one drop of a $FeCl_3$ solution which contains 2.5 mg. of $FeCl_3$ per ml.

o-Phenylenediamine gives a brownish-red solution.

m-Phenylenediamine gives a yellow solution.

p-Phenylenediamine gives a deep violet-blue solution.

Summary

A simple procedure for the identification of the three isomeric phenylenediamines is described.

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The Preparation of High-purity Anhydrous Magnesium Chloride[1]

JOHN S. PEAKE and WILLIAM L. FIELDER[2]

Introduction

A current research program on the measurement of densities and surface tensions of molten salt mixtures requires the preparation of pure, anhydrous magnesium chloride in pound quantities. Though many have worked on this problem in the past, the methods described in the literature are those pertaining either to industrial processes which yield a low-purity product or to methods which are difficult to carry out on any but a very small scale. Since the material required for our work must not attack platinum at 1000°C., it must be scrupulously free from carbon and other elements to which platinum is so sensitive at high temperatures.

Though magnesium chloride may be crystallized as the hexahydrate ($MgCl_2 \cdot 6H_2O$) in a very pure form, the problem involved in its use is one of removing the water from the hydrated material without permitting decomposition of the chloride through hydrolysis. The stepwise dehydration of the hydrate is shown in Table I.

TABLE I

Dehydration Reactions for Magnesium Chloride Hydrates

(a) $MgCl_2 \cdot 6H_2O \rightarrow MgCl_2 \cdot 4H_2O + 2H_2O$

(b) $MgCl_2 \cdot 4H_2O \rightarrow MgCl_2 \cdot 2H_2O + 2H_2O$

(c) $MgCl_2 \cdot 2H_2O \rightarrow MgCl_2 \cdot H_2O + H_2O$

(d) $MgCl_2 \cdot H_2O \rightarrow MgCl_2 + H_2O$

Reactions (a) and (b) in the above table can be carried out without appreciable hydrolysis by heating in a stream of air below 180°C. The removal of further water according to reactions (c) and (d) requires higher temperatures at which the following reactions set in:

(e) $MgCl_2 + H_2O \rightarrow MgOHCl + HCl$

(f) $MgCl_2 + H_2O \rightarrow MgO + 2HCl$

At lower temperatures reaction (e) takes place, but at high temperatures reaction (f) predominates. Many attempts have been made to restrain these hydrolysis reactions by using an atmosphere of dry hydrogen chloride but without complete success.

Another approach to the problem is to eliminate contact with water by reactions such as shown in Table II.

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TABLE II

(g) $Mg + Cl_2 \rightarrow MgCl_2$

(h) $Mg + 2HCl(g) \rightarrow MgCl_2 + H_2$

(i) $2Mg + TiCl_4 \rightarrow 2MgCl_2 + Ti$

(j) $2Mg + ZrCl_4 \rightarrow 2MgCl_2 + Zr$

(k) $Mg + S_2Cl_2 \rightarrow MgCl_2 + S$ (and MgS)

(l) $6Mg + 2QCl_3 \rightarrow 3MgCl_2 + Mg_3Q_2$
(Q = Group V element)

(m) $MgO + C + Cl_2 \rightarrow MgCl_2 + CO$

(n) $MgO + CCl_4 \rightarrow MgCl_2 + COCl_2$

All of these reactions suffer from the disadvantage of requiring very high temperatures and from the impossibility of avoiding contamination of the magnesium chloride product. Though the energy relations strongly favor reaction (g) ($\Delta F°298°K = -141{,}589$ calories), both this reaction and reaction (h) are prevented from going to completion due to the fact that magnesium chloride crystallizes in a layer lattice ($CdCl_2$-type) which causes it to form a stifling film which protects the magnesium from further attack by chlorine or by hydrogen chloride below the melting point of magnesium chloride (712°C.). The danger of impurities in the form of reaction by-products or unused reactants prevents the remainder of the reactions listed in Table II from being suitable for making magnesium chloride of high purity.

Another approach employed with considerable success by Richards (3) and later by Biltz and Huttig (1) is based upon the fact that ammonium carnallite ($NH_4Cl \cdot MgCl_2 \cdot 6H_2O$) gives up its water of crystallization with less tendency toward hydrolysis than does hydrated magnesium chloride. Though it is necessary to use a stream of dry hydrogen chloride to suppress hydrolysis, Biltz and Huttig were able to obtain a product reported to be 99.85% magnesium chloride.

Ueno (4) has reported work on the preparation of anhydrous magnesium chloride by means of the following reaction:

$$MgO + NH_4Cl \rightarrow MgCl_2 + NH_3 + H_2O.$$

By heating the reactants at 200-300°C. for magnesium oxide and at 400-490°C. for calcined magnesite, Ueno obtained anhydrous magnesium chloride contaminated with magnesium oxide. Gaskin (2) carried out the same reaction using magnesium hydroxide or magnesium basic chloride by heating them at 300-450°C. with ammonium chloride. He claimed a product containing 95% anhydrous magnesium chloride.

The experimental work reported herein consisted of a comparison of the most successful methods reported in the literature with another reaction investigated in this laboratory. The reaction not previously reported in the literature which shows considerable promise as a means of producing magnesium chloride of high purity in the completely anhydrous condition is the following:

$$Mg + 2NH_4Cl \rightarrow MgCl_2 + 2NH_3 + H_2.$$

The advantages inherent in this reaction are set forth in the following statements. 1. The reaction does not involve the elements of water, and no water can take part in the reaction or form any hydrates of magnesium chloride. 2. The reaction will proceed to completion within the temperature range of 200-400°C., thus avoiding contamination by reaction of hot magnesium chloride with the reaction container. 3. No non-volatile products are formed which might contaminate the product. 4. The reaction can be carried out in glass equipment of suitable design. 5. Magnesium of high purity (99.99%) is obtainable as a reagent. 6. Ammonium chloride can be recrystallized to remove impurities.

Experimental

Reaction of Magnesium with Ammonium Chloride

Twice-recrystallized ammonium chloride which showed a negative test for iron with α-α′dipyridyl reagent was mixed with +35 mesh chips of magnesium purified by treating the melt with zirconium to settle out impurities. The weight ratio of ammonium chloride to magnesium was 3:1. The mixture was placed in the small chamber (or ampoule) of the 30 mm. Pyrex combustion tube shown in Figure 1.

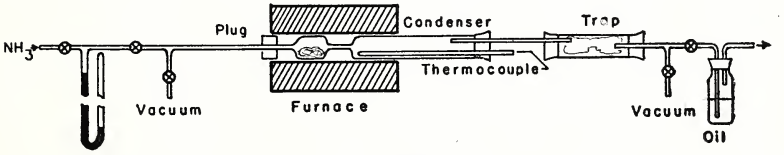

FIGURE 1

The tube was heated in an electric furnace commonly used for combustion analyses. The tube was connected, as shown in Figure 1, so that it could be evacuated or a stream of ammonia passed through it. The ammonia escaped through the oil trap which sealed the system against the atmosphere. Temperatures within the furnace were measured by means of a glass-enclosed thermocouple which projected into the larger portion of the combustion tube. The latter served as a condenser for excess ammonium chloride not consumed during the reaction. The air in the combustion tube was removed at the beginning of each experiment and was replaced by an atmosphere of ammonia which had been dried in the liquid state by means of sodium.

The sample was heated up slowly between 200 and 360°C. Two hours were allowed for completion of the reaction within this temperature range.

After completion of the reaction the excess ammonium chloride was distilled into the condenser. The ampoule (portion of the Pyrex tube containing the reaction mixture) was then sealed off under vacuum and separated from the remainder. When ready for analysis this sealed tube with the sample in it was broken under a known quantity of standard sulfuric acid solution. This was transferred to a volumetric flask with the washings of the beaker and glass fragments and diluted to a known

volume with distilled water. Aliquot portions of the sample were analyzed for magnesium ion, for chloride ion, and for total ammonia content. The ammonia present as ammoniate was calculated by back-titration of the excess of standard acid with standard base. The total ammonia content was determined by the Kjehldahl method. The magnesium ion was determined gravimetrically as the pyrophosphate. The chloride ion was determined gravimetrically as silver chloride.

Reaction of Magnesium Oxide with Ammonium Chloride

The apparatus used for this reaction was substantially the same as that for the magnesium-ammonium chloride reaction. The condenser in this case was longer and extended farther beyond the furnace. At the cold end of the condenser some sodium hydroxide pellets were placed to absorb the water evolved by the reaction. An atmosphere of dry, gaseous ammonia was used throughout the run.

The ampoule containing a mixture of magnesium oxide with about three times its weight of ammonium chloride was heated slowly to 360°C. over a period of two and one-half hours. The temperature was kept at 360-370°C. for another forty-five minutes and finally raised to 400°C. for a short period to remove ammonium chloride. The subsequent treatment of the material in the ampoule was identical to that outlined for the above reaction.

Dehydration of Ammonium Carnallite

The apparatus used for this reaction was that shown in Figure 2.

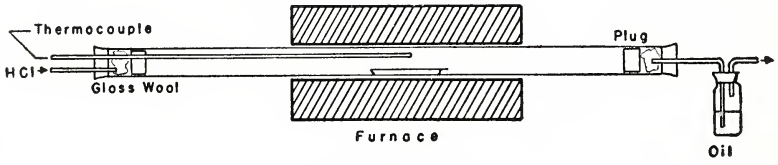

FIGURE 2

Equal weights of magnesium chloride hexahydrate crystals and of ammonium chloride were mixed in a clean evaporating dish. The mixture in the dish was then heated in air in an oven at 100°C. until it appeared to be dry, but it was not allowed to fuse. Some of the mixture was used to fill a glazed porcelain combustion boat which was then placed in a silica tube which could be heated by means of an electric furnace, as shown in the figure. The air was removed from the furnace tube and an atmosphere of dry hydrogen chloride passed through the silica tube during the heating operation. The tube was heated slowly to permit the temperature rise within the range of 200-360°C. to occur over a two-hour period to prevent hydrolysis. Over another period of four hours the temperature was raised to 750°C. to fuse the magnesium chloride formed. When cooled to 100°C. the boat containing the clear, fused salt was removed and then put into distilled water to dissolve the magnesium chloride. The quantities of magnesium and chloride ions were determined for the sample by the methods mentioned above.

Results

The experimental results are summarized in Tables III, IV, and V.

TABLE III

Reaction of Magnesium with Ammonium Chloride in Ammonia Atmosphere

NH_4Cl Used, grams	Mg Used, grams	Moles NH_4Cl Per Mole Mg Used	Mg Found, grams	Cl Found, grams
2.3064	0.3114	3.20	0.3125	1.0220
2.1388	0.2522	3.71	0.2525	0.7247
2.6004	0.3014	3.74	0.3010	0.9040
2.8701	0.3199	3.89	0.2842	0.9252
2.7027	0.5141	2.27	0.5155	1.5457
3.6814*	0.2986*	5.59*	0.2966*	0.8617*

Moles Cl : Mg	NH_3 Found, grams	Moles NH_3 : Mg	NH_4 Found, grams	Moles NH_4Cl : Mg	% Purity $MgCl_2$
2.020	0.3487	1.595	0.3934	0.204	99.01
1.969	0.4685	2.653	0.4663	None	98.45
2.006	0.3259	1.546	0.3372	0.053	99.70
1.985	0.3358	1.687	0.3850	0.247	99.25
2.002	0.4338	1.199	0.4533	0.054	99.90
1.992*	0.0025*	0.012*	0.0027*	None*	99.60*

* Sample heated under vacuum to remove ammonia and ammonium chloride.

TABLE IV

Reaction of Magnesium Oxide with Ammonium Chloride in Ammonia Atmosphere

NH_4Cl Used, grams	MgO Used, grams	Moles NH_4Cl Per Mole MgO Used	Mg Found, grams	Cl Found, grams
1.7804	0.4135	3.24	0.1830	0.5131
2.3940	0.3732	4.85	0.1673	0.5121
2.1043	0.4566	3.50	0.2088	0.5850
2.2843	0.4930	3.50	0.2205	0.6858

Moles Cl : Mg	NH_3 Found, grams	Moles NH_3 : Mg	NH_4 Found, grams	Moles NH_4Cl : Mg	% Purity $MgCl_2$
1.934	0.3938	3.072	0.3928	None	98.15
1.983	0.5427	4.633	0.5557	0.116	99.15
1.915	0.2343	1.603	0.2352	0.006	95.75
2.055	0.5544	3.589	0.5664	0.078	97.32

TABLE V

Dehydration of Ammonium Carnallite in Hydrogen Chloride Atmosphere

Mg Found, grams	Cl Found, grams	Moles Cl : Mg	% Purity $MgCl_2$
0.0714	0.2110	2.027	98.67
0.0414	0.1231	2.039	98.09
0.0725	0.2117	2.012	99.40

Note: Calculation of purity in above tables based on Cl : Mg ratio only.

Discussion of Results

Reference to the data as presented above shows the highest degree of purity of the magnesium chloride based on the Cl: Mg atomic ratio was obtained from the magnesium-ammonium chloride reaction. Next highest purity was obtained by the dehydration of ammonium carnallite. The magnesium oxide-ammonium chloride reaction yielded the material of lowest purity. The justification for disregarding the ammonia and ammonium chloride present in the products of the reactions of ammonium chloride with magnesium and with magnesium oxide lies in the nature of the purpose to which the material is to be put, since it is to be fused when put to its ultimate use.

Choice between the methods described above as means of preparing quantities of anhydrous magnesium chloride of high purity depends upon the relative ease with which the larger-scale operations can be carried out. The data presented do not make a choice on this basis possible. Subsequent work must be done to serve as a basis for such a choice.

From the results it is obvious that anhydrous magnesium chloride tenaciously retains some ammonia and some ammonium chloride at temperatures up to 400°C. unless these are removed by heating under vacuum or by fusing the ammonium chloride product. This tenacity with which these substances are held shows the fairly strong tendency toward compound formation. Biltz and Huttig (1) studied the ammoniates of magnesium chloride and other magnesium halides and found the existence of several definite ammoniates. Some additional work performed by the authors but not reported in this paper shows the existence of a definite ammoniate, $MgCl_2 \cdot NH_3$, whose decomposition pressure was measured, but time did not allow completion of the system.

It is particularly interesting that the reaction between magnesium metal and ammonium chloride proceeds at a temperature so very much lower than that for the reaction of magnesium with either free chlorine or with hydrogen chloride. This is further pointed up by the fact that gaseous ammonium chloride has been shown by other investigators to be completely dissociated into ammonia and hydrogen chloride. Why does the reaction proceed readily at a low temperature in hydrogen chloride containing ammonia but not below the melting-point of magnesium chloride in its absence?

The authors believe that the answer lies in the existence of stable ammoniates of magnesium chloride. The $CdCl_2$-type lattice of magnesium chloride mentioned above is of such a structure that it forms a protective film of the salt over the metal, effectively sealing the metal against further attack by chlorine or hydrogen chloride until the melting-point of the chloride is reached. This melting action destroys the ability of the chloride to protect the metal from attack. In the presence of ammonia one does not get pure magnesium chloride which would have a stifling action on the reaction. Instead one obtains certain ammoniates of magnesium chloride which have different crystal structures and which do not form protective films.

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The Catalytic Hydrogenation of Tyrosine[1]

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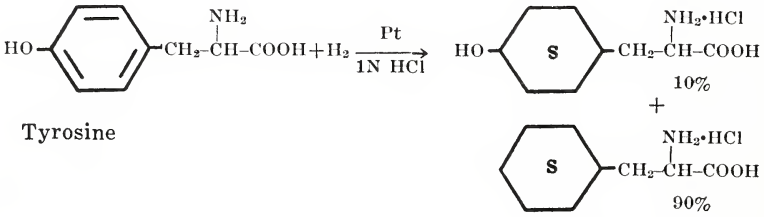
In connection with another research project we became interested in the catalytic reduction of tyrosine.

It was shown by Waser (2-6) and Karrer (1) that tyrosine could be hydrogenated by means of a platinum catalyst to produce a mixture of hexahydrotyrosine and β-cyclohexylalanine which is extremely difficult to separate.

Since we were interested in preparing β-cyclohexylalanine, the experiments of Waser and Karrer were repeated with the confirmation of their results. However, we were able to complete the hydrogenation in about an hour or less as compared to the two or three days as described by Waser (4). This difference was probably due to a difference in the activity of the two catalysts.



Tyrosine

Because of the difficulty involved in obtaining pure β-cyclohexylalanine by the aforementioned procedure, a thorough study of the reaction was made. From this investigation a method was developed whereby both L(–)– or DL-β-cyclohexylalanine can be made quantitatively in a two hour period.

The fundamental difference between the two procedures is that Waser and Karrer used a 1 N. hydrochloric acid solution as the reaction medium whereas we employed a solution consisting of a 1.5-2 N. hydrochloric acid and ethyl alcohol.

The difference in the results may be due to the fact that the β-cyclohexylalanine hydrochloride, which is formed in the reaction, is insoluble in the hydrochloric acid solution while it is soluble in the alcohol-hydrochloric acid mixture. In the former case the amino acid salt probably precipitates on the surface of some of the platinum catalyst and as a consequence affects the efficiency of the catalyst.

Table I shows some of the experiments that were performed and the results that were obtained under various conditions.

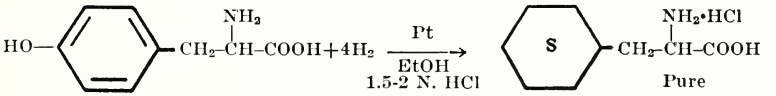
1. Contribution No. 624 from tre Chemistry Department, Indiana University.

TABLE I

Moles of Tyrosine	Solvents Used	Theoretical Moles of H_2	Actual Moles of H_2	Time in Minutes	Type of Catalyst
0.055	155 ml. 1 N HCl	0.236	0.288	85	2 g. fresh PtO_2
0.055	105 ml. 1.7 N HCl	0.229	0.220	70	1.1 g. fresh moist PtO_2
0.044	138 ml. 1.1 N HCl	0.189	0.180	75	1.5 g. fresh moist PtO_2
0.027	158 ml. 0.45 N HCl	0.118	0.106	25	0.75 g. fresh moist PtO_2
0.055	50 ml. water 30 ml. 95% ETOH, 15 ml. Conc. HCl	0.227	0.227	120	0.75 g. fresh moist PtO_2
0.083	100 m. water 50 ml. 95% EtOH 20 ml. Conc. HCl	0.3455	0.341	120	1.5 g. moist fresh catalyst

The theoretical moles of hydrogen are based on the hydrogen needed to reduce the tyrosine and the platinum oxide catalyst.

One of the major difficulties encountered in the synthesis of amino acids is that they are generally produced in the form of their hydrochloride salt from which they must be isolated. This is frequently one of the most troublesome steps of the synthesis when one is interested in securing a high yield. The β-cyclohexylalanine was no exception to the general rule. After trying the numerous methods customarily used for this purpose, with little success, a new approach was used in which lithium carbonate was employed to remove the hydrochloric acid.



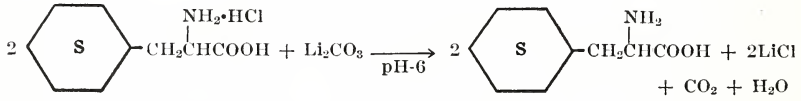
The advantage of the latter method is that the removal of the hydrochloric acid is quantitative due to the fact that the lithium chloride which is formed in the reaction mixture may be extracted with organic solvents leaving behind the precipitated amino acid free of any salts. In this manner a 95-98 per cent yield of the free amino acid can be obtained from the hydrochloric acid salt.

Numerous organic solvents were tried for this purpose including n-butyl alcohol, n-amyl alcohol, isoamyl alcohol, isopropyl alcohol, ethyl alcohol, and methyl alcohol. Of all those tried, a fifty per cent ethyl alcohol-water mixture was found to be the most effective.

The N-acetyl, N-benzoyl and N-phthalyl derivatives of L-β-cyclohexylalanine were prepared for characterization purposes. However, in many instances complete racemization occurred during the preparation of the benzoyl derivative.

Experimental

L-β-Cyclohexylalanine hydrochloride:—A solution consisting of 15 grams (0.083 moles) of L-tyrosine, 100 ml. of water, 50 ml. of 95% ethyl alcohol and 20 ml. of concentrated hydrochloric acid was prepared in a citrate bottle. One and twenty-five hundredths grams of moist platinum oxide was added and the mixture hydrogenated at 40-20 pounds per square inch. When the theoretical amount of hydrogen was absorbed the solution was decanted from the catalyst and evaporated to dryness at forty millimeters pressure between 60°C. and 70°C. The residue was treated with 100 ml. of water and again evaporated to dryness as before. The dried amino acid hydrochloride was placed in a vacuum desiccator over sodium hydroxide at one mm. pressure. The dried crude amino acid hydrochloride weighed 17.3 grams. No attempt was made to further purify this product.



L(+)-β-cyclohexylalanine:—Fifteen grams of the crude amino acid hydrochloride was dissolved in 200 ml. of 50 per cent ethyl alcohol-water solution which was heated to 95°C. The stoichiometric quantity of lithium carbonate was added to the vigorously stirred solution. The mixture was cooled slowly to room temperature and then placed in a refrigerator. The precipitate was filtered and washed with water until no test for the chloride ion could be obtained. When dried the β-cyclohexylalanine weighed 12.4 grams or 96.8 per cent of the theoretical amount. This product showed a rotation of $\alpha_{D}^{20^\circ} = +13.48$ when 1 g. of it was dissolved in 15 ml. of ethyl alcohol and 10 ml. of 4% hydrochloric acid. Anal. Calc'd for $C_9H_{17}O_2N$: N, 8.19% Found: N, 8.18%.

L(−)-N-Acetyl-β-cyclohexylalanine:—Ten grams (0.0585 moles) of 1-β-cyclohexylalanine was added to 100 ml. of twenty per cent sodium hydroxide in a 500 ml. flask at five degrees centigrade. Twenty-five milliliters of acetic anhydride was added to one half milliliter portions. The mixture was stirred mechanically, while the temperature was kept below ten degrees centigrade. Concentrated hydrochloric acid was added while the temperature was maintained below 10°C. until the pH of the solution was four. The precipitated acetyl derivative when filtered and dried at 100°C. weighed ten grams. Purified by recrystallization from ethyl alcohol it melted at 205-206° Corr. N. E. Calc'd: 213, Found 213. One gram dissolved in twenty milliliters of 95% ethyl alcohol at 25°C. gave an optical rotation of $\alpha_{D}^{25^\circ} = -3.68^\circ$.

L(−)-N-benzoyl-β-cyclohexylalanine:—Two grams of the 1-β-cyclohexylalanine was dissolved in 20 ml. of 1.0 N sodium hydroxide at 50°C.

Five grams of benzoyl chloride was added and the mixture stirred for twenty-five minutes. Thirty milliliters of 20 per cent sodium hydroxide was slowly added while the temperature of the solution was maintained at five degrees. The solution was acidified with hydrochloric acid and the residue filtered. The product was recrystallized from alcohol and water and melted at 122-124°C. Corr. Karrer (1) reported that the L(–) isomer melted at 124-125°. N. E. Calc'd 275, Found 278. Anal. Calc'd for $C_{16}H_{21}O_2N$, Found 5.14 nitrogen, Calc'd 5.10.

L(–)-N-Phthalyl-β-cyclohexylalanine:—Two grams of 1-β-cyclohexylalanine (0.117 moles) was mixed with 1.85 grams of phthalic anhydride in a test tube. The tube was inserted in an oil bath at 185°C. and the melt stirred with a glass rod. When bubbling ceased, the mixture was cooled and the solid removed from the test tube. The solid was recrystallized twice from a mixture of alcohol and water and dried over phosphorus pentoxide at 76°C. in vacuum. The melting point was 157-158°C. Corr. N. E. Calc'd 301, Found 301.

Summary

L-Tyrosine has been successfully hydrogenated to L-β-cyclohexylalanine hydrochloride, in quantitative yields using platinum as the catalyst. The time required was two hours as compared to several days by previous methods.

The L-β-cyclohexylalanine hydrochloride has been converted to the free amino acid in 96 per cent yields by the use of lithium carbonate and organic solvents.

L(–)-N-Acetyl-β-cyclohexylalanine, L(–)-N-benzoyl-β-cyclohexylalanine and L(–)-N-phthalyl-β-cyclohexylalanine were also prepared. The acetyl and the phthalyl derivatives have not been reported previously in the literature.

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A Spectrophotometric Method for the Determination of Water

Byron L. Ferguson and Nancy M. Coulter,[1] Valparaiso University

In 1864, Winkler (3) observed that a solution of cobaltous chloride in absolute ethanol was colored a deep blue at room temperature and that upon extreme dilution the solution retained a distinct blue color. It was also observed that the addition of water to this solution caused a color change from the blue, through violet, to pink. While this observation stimulated interest in the mechanism of the color change, the obvious application of this phenomenon received little attention. Recently, however, Ayres and Glanville (1) have reported a spectrophotometric method for the quantitative determination of water in ethanol utilizing the measurable relationship between the color of a cobaltous chloride-ethanol solution and the water concentration. Pfister and Kerley (2) have reported a similar method for the determination of water vapor in fuel gas using a cobaltous bromide-butanol solution. Both of these methods have a specific rather than a general application and an attempt is made through this investigation to outline a spectrophotometric method for the determination of water which has a broader application and which is both convenient and accurate.

General Procedure

A 1-5 gram sample of the substance containing adsorbed water is weighed into 50 ml. of absolute ethanol having a rated purity of 99.98%. The mixture is shaken vigorously for 5-10 minutes and the suspended material allowed to settle. Centrifuging may be necessary. An aliquot portion of the clear supernatant liquid is pipeted into a 50 ml., glass stoppered, volumetric flask, stock cobalt-ethanol solution is added in sufficient amount so that upon dilution the cobalt concentration will be 300 ppm., the flask is filled to the mark with absolute ethanol, and the solution mixed thoroughly. All volumetric measurements are made at 25± 0.1°C. The transmittancy of the sample solution is measured at 671mμ against absolute ethanol as the solvent and the amount of water present is determined by referring to a standard water-ethanol curve. All transmittancy measurements are made with a Beckman Model DU spectrophotometer using matched Corex cells and for the best results the cell compartment should be thermostated at 25±0.1°C.

Transmittancy Curves

Transmittancy-wavelength curves for cobalt-ethanol solutions, plotted over the wavelength range 450-750mμ, showed a minimum transmittancy at 671mμ. The concentration of cobalt does not effect the position of the minimum, however, the presence of water causes a slight shift in position toward the longer wavelengths. This is to be expected since the

1. Present address: Bendix Aviation Corporation.

concentration of the pink aquo complex increases as the amount of water increases. Within the practical range of measurement, the minimum transmittancy of cobalt-water-ethanol solutions remains essentially constant at 671mμ.

Effect of Cobalt Concentration

The cobalt concentration determines the optimum range for the measurement of water concentration. Since cobalt-water-ethanol solutions do not obey Beer's Law, due to the formation of the aquo complex, the conditions for the measurement must be adjusted so that deviations from the law are minimized. A plot of log percent transmittancy against cobalt concentration illustrates the poor conformity to Beer's Law of cobalt-ethanol solutions even without water, however, the linear portion of the curve is in fair agreement and this suggests that the optimum cobalt concentration lies between 100 and 400 ppm.

A plot of percent transmittancy against log concentration of water for water-ethanol solutions containing first 200, then 300, and finally 400 ppm. cobalt showed that as the cobalt concentration increased, the measurable range of water concentration shifted to higher concentrations. For 300 ppm. cobalt the optimum range is from 2-10 mg. water per ml. A cobalt concentration of 300 ppm. was chosen for this determination because the ratio of the transmittancy change to change in water concentration appears to approximate that which is predicted by Beer's Law.

Effect of Time

Solutions containing 300 ppm. cobalt and varying amounts of water were measured at 671mμ and their percent transmittancy noted at five minute intervals for a period of one hour. Reproducible transmittancy readings were obtained for these solutions within ten minutes of their preparation and no noticeable change in the transmittancy was observed after one week.

Effect of Temperature

For the range 20-30°C. the transmittancy decreases approximately 1% for each degree rise in temperature. The change appears to be reversible and without effect upon the minimum transmittancy. Since the temperature has such a large effect upon the transmittancy, all solutions are thermostated at 25$\pm$ 0.1°C. before and during all transmittancy measurements.

Results of Analysis

The amount of adsorbed water in a variety of substances was determined spectrophotometrically and the values obtained checked against a Karl Fisher analysis. The results summarized in Table I are reported in milligrams of water per gram of sample.

TABLE I

Comparison of Results of Spectrophotometric and Karl Fisher Methods of Determining Water

Sample	Spectrophotometric	Karl Fisher
Sawdust	85.0	84.0
Bauxite	75.5	75.4
Cereal	2.5	2.7
Soybean mash	67.8	68.4

Summary

The change in color of cobalt-ethanol solutions from blue to pink with an increasing amount of water provides a means of quantitatively analyzing for adsorbed water if the cobalt concentration is maintained at 300 ppm., the temperature is constant to 0.1°C., and the sample is insoluble in absolute ethanol. When these conditions are observed, this spectrophotometric method may be substituted with accurate results for the widely accepted Karl Fisher method.

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A Study of the Preparation and Anticoagulant Properties of Some Phosphorylated Proteins[1]

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Interest in blood anticoagulants has increased since 1946 when the American Heart Association appointed a committee to evaluate the use of anticoagulants in the treatment of coronary thrombosis, which causes about 200,000 deaths annually. A report of this committee showed that the death rate of individuals treated with anticoagulants was significantly lower than for a control group which did not receive such treatment.

The normal anticoagulant present in the blood is heparin. This compound as well as dicoumarol are used clinically in the treatment of coronary thrombosis, but both have distinct limitations. Heparin is expensive, is not very effective unless given intravenously and its anticoagulant effect lasts for only a few hours necessitating continual injections. Dicoumarol can be given orally but there are several serious disadvantages in its use, such as delayed action, persistence of its action for several days which can be relieved only by transfusion, and capillary dilation which may result in undesirable bleeding. Because of the limitations of heparin and dicoumarol there has been extensive search for an inexpensive, nontoxic substance with anticoagulant action equal to heparin. Thus far no such anticoagulant has been found. Extensive testing of many compounds has indicated that some of the requirements of an anticoagulant are that it must be water soluble, have a high molecular weight and contain combined sulfuric acid or other acid groups of similar strength.

Certain sulfated proteins prepared by the methods of Reitz and coworkers (8) (9) using concentrated sulfuric acid and pyridine-chlorosulfonic acid were found by Reitz and Cords (7) to have anticoagulant activity equal to approximately 1/10 that of heparin. These sulfated derivatives were found to be relatively non-toxic so that it would be possible to use them clinically. Thus encouraged, it was decided to investigate the possible anticoagulant activities of phosphorylated proteins.

Preparation of Derivatives

Materials to be phosphorylated were first ground to pass through a 200 mesh sieve. The phosphorylation procedure was similar to that of Ferrel, et al. (1). The phosphorylating reagent was prepared by introducing 94 g. of phosphorus pentoxide into 125 g. of 85 per cent orthophosphoric acid and stirring until all of the oxide had dissolved. Phosphorylation was accomplished by slowly dusting 1 g. of the material into 100 g. of the cooled reagent and stirring until a smooth dispersion was obtained. The dispersion was then placed in a dessicator over phosphorus pentoxide and allowed to react at room temperature for 72 hours. Following the reaction period the very viscous liquid was diluted with cold

1. Taken from a thesis submitted by M. M. Mozen to the faculty of the Graduate School, Purdue University, in partial fulfillment of the requirements for the degree Master of Science, 1952.

distilled water and poured over cracked ice. This solution was neutralized to pH 7.0 with 10 normal sodium hydroxide, adding cracked ice to maintain the temperature below 5° C. Toluene was added to prevent bacterial action and the solution dialyzed in cellophane tubing against distilled water until no phosphate ion could be detected in the dialysate. This required from three to five days. After concentration of the solution in the dialysis tubes by hanging them in a current of warm air, they were dialyzed for five days against 10 per cent sodium chloride to remove loosely bound phosphorus. Following this the sodium chloride was removed by dialyzing against distilled water until the dialysate gave a negative test for chloride ion. At this stage of the preparation an insoluble portion was usually observed. This was removed by centrifugation and dried by washing with alcohol and ether. The soluble portion was concentrated to a small volume and lyophilized.

Very low yields were obtained when soybean protein, blood fibrin and lactalbumin were phosphorylated by the exact procedure of Ferrel. The values shown in Table I for these proteins were obtained by using only

TABLE I

Yield, Composition and Anticoagulant Activity of Phosphorylated Materials

Material	Nitrogen content % (a)	Moles of phosphate P per 10^4 g. of orig. protein (b) (a)	Yield insoluble phos. deriv. %	Yield soluble phos. deriv. % (a)	Phosphate P. in sol. fraction % (a)	Anticoag. activity ACU/mg.
Phos. Zein	10.9	13.5	4.23	105.0	2.9	1.7
Orig. Zein	15.5	....	....	....	...	...
Phos. Gliadin	13.2	12.5	1.09	50.0	3.1	1.3
Orig. Gliadin	16.7	....	....	....	...	...
Phos. Bovine Albumin	12.1	13.3	0.54	34.0	3.5	0.7
Orig. Bovine Albumin	14.4	....	....	....	...	...
Phos. Soybean Protein	9.6	21.0	13.00	29.8	4.5	1.0
Orig. Soybean Protein	13.9	....	....	....	...	...
Pros. Blood Fibrin	8.5	14.9	3.54	40.8	2.4	1.0
Orig. Blood Fibrin	16.2	....	....	....	...	...
Phos. Lactalbumin	12.8	9.3	6.44	27.2	2.7	1.3
Orig. Lactalbumin	13.4	....	....	....	...	...
Phos. Casein (c).	15.6	26.3	28.50	28.6	7.6	1.7
Orig. Casein (d).	16.7	....	....	....	...	...
Phos. Pectin	...	....	16.2	96.0	3.5	1.3

(a) Calculated on a moisture free basis

(b) Moles of phosphate phosphorus per 10^4 g. of protein $= \frac{100 \times \text{per cent P in phos. deriv.} \times \text{per cent N in orig. protein}}{31 \times \text{per cent N in phos. deriv.}}$

(c) Prepared using phosphoric acid and urea

(d) Original casein contained 1.14 per cent P

90 g. of phosphorylating reagent to one g. of protein. This change reduced the large amount of sodium phosphate formed during neutralization, shortened the time required for dialysis and possibly decreased the amount of protein hydrolysis, thus increasing the yield.

When the preparative work was almost completed a patent by Olcott and Mohammad (5) came to our attention. It described the phosphorylation of proteins by the use of phosphoric acid and urea. This method employed higher temperatures than Ferrel's method but much less phosphoric acid was required and the reaction time was reduced from 72 hours to 30 minutes. The phosphorylated casein listed in Table I was prepared by mixing 10 g. of the protein with 3 ml. of water for thorough wetting, then adding 3 g. of urea followed by only 2.5 ml. of phosphoric acid. The thick gel that resulted was heated at 140° C. for 30 minutes, then diluted with water, poured over cracked ice and neutralized to pH 7.5. Isolation of the product in this case required less time as much smaller quantities of salts needed to be removed by dialysis. The values for casein shown in Table I indicate that more phosphorus is introduced by this method but that the yield of insoluble material is more than twice as high as that obtained by the other method.

Analysis of Derivatives

Phosphorus content of the products was determined by the method of Fiske and Subbarow (2). Samples were digested with sulfuric acid, decolorized with hydrogen peroxide, diluted and boiled to decompose pyrophosphate and any residual hydrogen peroxide. The blue color that formed on addition of ammonium molybdate and 1,2,4-aminonaphtholsulfonic acid to known aliquots was allowed to develop 10 minutes and read in an Evelyn photoelectric colorimeter using a 660 millimicron filter.

The total nitrogen content of the derivatives was determined by a micro-Kjeldahl method described by Hawk, Oser and Summerson (3). Digestion of the phosphorylated derivatives was carried out by heating three hours with 5 ml. of ten normal sulfuric acid followed by decolorization with hydrogen peroxide. Use of catalysts was avoided because they interfered with subsequent phosphorus determinations.

The percent of nitrogen and phosphorus in the soluble derivatives is shown in Table 1. Phosphorus content of the soluble derivatives was also calculated on the basis of moles of phosphorus per 10^4 g. of the original protein. These values are more significant than the percentage figures alone in assessing the amount of phosphorus introduced since the nitrogen content of both the original and the phosphorylated derivatives is included in their calculation.

Assay of Anticoagulant Activity

The heparin assay method of Quick (6) was used because of its simplicity, convenience and because it had been used for similar studies (7). This method is based on the assumption that heparin forms an antithrombin with a component of the plasma and that the amount of the antithrombin can be quantitatively measured by determining the quantity of thrombin it will neutralize. The assumption that phosphorylated proteins act in the same manner as heparin seems justified since anticoagulants of similar

structure have been shown to act by this mechanism. Thrombin Topical, manufactured by Parke-Davis, was used instead of the thrombin ordinarily prepared from bovine plasma. For purposes of comparison one anticoagulant unit (ACU) is defined as that amount of moisture free material which when added to freshly oxalated plasma will neutralize 0.1 ml. of full strength thrombin solution in 10 minutes at 37° C. A standard heparin solution containing 0.5 mg. per ml. was assayed to contain 100 ACU per mg. The results of the determinations of the anticoagulant activities of seven phosphorylated proteins as well as a carbohydrate, pectin, are assembled in Table I. It will be noted that none of the derivatives has an anticoagulant activity greater than about two per cent that of heparin. Corresponding soluble sulfated derivatives were found by Reitz and Cords (7) to have about ten per cent the anticoagulant activity of heparin. No adequate explanation has been found as to why the phosphorylated derivatives should have so much less anticoagulant activity than the corresponding sulfated derivatives. Similar results, however, were reported by Karrer et al. (4), who found that derivatives prepared by the phosphorylation of certain polysaccharides and gelatin had very low anticoagulant activity. They offered no explanation for the low activity. Possibly the presence of a phosphatase in plasma or the fact that a considerable portion of the phosphorus in the derivatives is present as metaphosphate may in part explain the results.

Summary

Phosphorylated derivatives of seven proteins and a carbohydrate were prepared. A phosphorylating reagent employing urea and phosphoric acid was found to be superior to one consisting of phosphoric acid containing excess phosphorus pentoxide. The anticoagulant activities of these derivatives was found to be about two per cent that of heparin.

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An Improved Laboratory Preparation of Alkyl Cyanides

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Widely used laboratory manuals (1), (3), describe refluxing an aqueous solution of sodium cyanide with methanol and n-butyl bromide for 25-30 hours and carefully distilling off the methanol before isolation of n-butyl cyanide. The use of a higher boiling solvent and a much shorter reflux period has been studied. A yield equal to those in the above references (65-70%) has been obtained by refluxing for only two hours with cellosolve. The addition of small amounts of potassium iodide increase the yield. Very much lower yields were obtained when butyl bromide was replaced by butyl chloride, with or without the addition of an iodide. Yields of n-propyl cyanide are somewhat lower than those for n-butyl cyanide. These modifications have been used with advantage for several years by students in organic preparation courses.

Experimental

Two balls of 96% sodium cyanide (51 g.) (1 mole) and 2.0 g. potassium iodide are dissolved in 65 ml. of water by heating under reflux and 130 ml. cellosolve and the alkyl halide (118 g. n-butyl bromide) added. Reflux vigorously for two hours using a bulb condenser, add 200 ml. of water and distil until no more water insoluble material passes over. Separate the upper layer and wash it in turn with equal volumes of 40% calcium chloride solution, water, cold 50% sulfuric acid (to remove the isonitrile formed in the reaction) and saturated sodium bicarbonate solution. After drying with anhydrous calcium chloride, distil using a Vigreaux column. The product is collected at 138-140°/737 mm. The yield is 67 and 68% in two runs and with the forerun redried and redistilled the yield is increased to 74-75%. The product has a refractive index at 25° C. of 1.3955. The literature value (2) is 1.3950.

n-Butyl cyanide from n-Butyl bromide

g. moles RBr	g. KI	% xs NaCN	hrs. reflux	% yield n-BuCN
0.89	2	10	3.3	63
0.69	2	50	3.3	58
0.91	2	10	4.6	69
0.91	None	10	4.6	54
0.88	2	16	2.0	67
0.88	2	16	2.0	68

n-Butyl cyanide from n-Butyl chloride

g. moles RCl	g. KI	% xs NaCN	hrs. reflux	% yield	recovery BuCl	corrected % yield
1.45	5	10	4	12	61	30
1.41	5	10	12	28	26	38
0.88	None	10	9	20	50	40

n-Propyl cyanide from n-Propyl bromide

g. moles RBr	g. KI	% xs NaCN	hrs. reflux	% yield n-PrCN
0.95	3	10	2.5	55
0.90	3	10	3.7	48
0.95	3	5	3.7	52

Yields were taken after two or three fractional distillations of product boiling 113-117° at 738 mm. The refractive index at 25° was 1.3815-1.3826 compared with a literature value (2) of 1.3820.

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The Spectrophotometric Determination of Nitrate Ion in 75% Sulfuric Acid[1]

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While investigating the color-forming reactions of 4,5-dihydroxynaphthalene-2,7-disulfonic acid (chromotropic acid) with various cations in concentrated sulfuric acid, it was observed that salts containing an ionizable nitrate group produced an intense yellow color.

Qualitative tests indicated that the color intensity varied with nitrate concentration. It was also observed that few other anions produced competing colors. Oxidizing agents such as bromates and iodates yielded the color of free bromine and iodine.

Therefore because of the promising nature of the colored species, and because of the need for a better colorimetric method for nitrate, the system of chromotropic acid, nitrate and sulfuric acid was investigated with reference to the possibility of devising a quantitative analytical procedure.

Experimental

A 0.01 M. nitrate solution was prepared by dissolving ammonium nitrate in 95% sulfuric acid. A 0.025 M solution of chromotropic acid was prepared by dissolving the sodium salt in 95% sulfuric acid. These solutions are instable when exposed to light and the reagent must either be stored in the dark or, preferably, made up before each analysis. All photometric data were obtained from the General Electric recording spectrophotometer using 1 cm. cells.

The Nitrate-Chromotropic Acid System

The spectrophotometric curve shows the presence of an absorbance maximum at 416μ. Solutions of ammonium nitrate, chromotropic acid and sulfuric acid were prepared differing only in the per cent of acid (by volume). No appreciable color develops when the solution is less than 50% sulfuric acid. From the standpoint of color intensity, it is apparent that any concentration of acid from 60% to 95% would be satisfactory, but the color stability (to be mentioned later) dictates use of approximately 75% sulfuric acid.

These investigations showed, further, that if the solutions are prepared by diluting 95% sulfuric acid with water, the heat generated seriously alters the shape of the absorption spectrum. Because of this, it is necessary to add the chromotropic acid reagent to the nitrate solution while simultaneously cooling it in a cold water bath. This removes the interference.

The absorbance decreases with increasing temperature of the solutions after color formation. Thus, for a five degree change in temperature

1. Abstracted from a thesis submitted by Bruce A. Swinehart to the Graduate School, Purdue University, in partial fulfillment of the requirements for the Master of Science degree, 1953.

the absorbance changes only 0.006 to 0.015 units, a maximum change of under 2%. Therefore, exact temperature control is not necessary since small fluctuations in temperature will not cause serious error in concentration measurements.

Color Stability

A series of solutions varying in nitrate concentrations, and containing 5 x 10^{-3}mμ. in chromotropic acid were prepared in 95% sulfuric acid. In addition to fading, the absorbance curve for any given concentration of nitrate was not reproducible. In 85% sulfuric acid, fading was again present though less pronounced.

A time study was made on two 2 x 10^{-4} M nitrate and 5 x 10^{-3} M chromotropic acid solutions in 75% sulfuric acid. Complete color development occurs within a few minutes after mixing. The system is then stable for a period of two hours following which it begins to fade slowly.

Precision Studies

The precision of the method was determined for concentrations at the middle and the extremes of the applicable concentration range. Six separately prepared samples were analyzed at each concentration. The average absorbance value, the standard deviation and the corresponding uncertainty in the estimation of the nitrate were determined. The standard deviation represents errors of $\pm$8% at 10^{-5} M nitrate to $\pm$0.5% at 4 x 10^{-4} M.

Interferences

The interference of various anions and cations was determined by measuring solutions in which the diverse ion concentration was one hundred times the nitrate concentration. The absorbance was then compared to a similar solution containing only the nitrate ion.

Under these conditions acetate, fluoride, perchlorate, magnesium and copper show no interference. Cyanate, phosphate, aluminate, zinc and calcium interfere but slightly. Thiocyanate and tetraborate almost completely destroy the color. Iron and chlorides interfere seriously. Nitrites produce the same color as nitrates. It seems likely that the nitrite is oxidized to nitrate and interferes simply by formation of additional color. Attempts to prevent this color formation by the addition of reducing agents, both before and after addition of the nitrite, were unsuccessful.

Chloride ion is known to be one of the chief interferences in colorimetric nitrate determinations. It was, therefore, studied in somewhat greater detail. The system was investigated using various amounts and ratios of nitrate ion, chloride ion, and chromotropic acid. The results demonstrated that a large excess of chloride cannot be tolerated and that the larger the nitrate concentration, the greater the effect of the chloride ion.

Summary

The method for the determination of nitrate using chromotropic acid in 75% sulfuric acid is applicable in the range of 0.1 to 7.0 parts per mil-

lion. The accuracy is observed to be about ±3%. The method compares favorably with other colorimetric methods for the determination of nitrate ion from the standpoint of sensitivity, convenience, reliability and interferences.

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Homomolecular Reactions: A New Field of Study in Chemistry

W. H. JOHNSTON, Purdue University

Among the interesting new researches which have been made possible by the ready availability of enriched stable isotopes and mass spectrometers is the reaction of a molecule with itself. More rigorously stated, this is a reaction of a molecule with an identical molecule during which identical atoms are interchanged. It is proposed that these reactions be called homomolecular exchange reactions.

An interesting example is the homomolecular reaction of oxygen which we have studied (1) using a sample (2) of oxygen enriched to twenty-five per cent oxygen —18. Initially this sample contained a non-equilibrium mixture of the molecular species O_2^{32}, O_2^{34}, and O_2^{36}. Mass spectrometric measurements were used to follow the approach to a random distribution of the heavy isotope. An example of one of the exchange reactions producing this change is

$$O_2^{18-18} + O_2^{16-16} \rightarrow O_2^{18-16} + O_2^{18-16} \qquad (1)$$

We have shown that this reaction does not proceed thermally, even in the presence of the specie, O_4, in the liquid state. On the other hand a rapid photochemical exchange is produced by appropriate ultraviolet radiation.

In general in the case of a one-element diatomic molecule, the use of two stable isotopes makes possible the preparation of a non-equilibrium mixture of the three molecular species. Such an initial non-equilibrium distribution will approach equilibrium through a simple exchange reaction according to the equation (3),

$$\ln(1-\alpha) = \frac{-2Q}{N} \cdot t \qquad (2)$$

where Q is the rate of exchange, N is the number of molecules, and t is the time for a measured fraction of exchange, α. The expression for α is

$$\alpha = \frac{f_i^\circ - f_i}{f_i^\circ - f_{i\infty}} \qquad (3)$$

in terms of the change in the fraction of any one of the molecular species, i, and its complete change to the equilibrium fraction corresponding to a random isotopic distribution. In this expression f_i° and $f_{i\infty}$ are the initial and equilibrium fractions, respectively.

It is interesting to note that the rate of exchange, Q, in Equation (2) refers to the overall rate of exchange independent of change in isotopic composition. Thus this equation allows us to obtain the actual rate of reaction between identical one-element molecules. Similar expressions apply to a two-element molecule, such as nitric oxide; however, they necessarily involve double tagging or the use of an enriched isotope of each element.

Another homomolecular reaction which we have studied is that of the nitrogen molecule (4). In view of the great strength of the nitrogen bond it is perhaps not surprising that no reaction was observed in days at 850°C. However, a reaction does occur in a glow discharge (4, 5) in the presence of active nitrogen.

In the homomolecular exchange of oxygen, photochemically, and of nitrogen in a glow discharge the kinetics of these reactions confirm the derived law, Equation (2). These kinetics make possible an understanding of the mechanisms of these reactions and provide interesting kinetic data for the application of absolute rate theory to extremely simple chemical reactions in which there is no change in stoichiometry. Despite this simplicity it is interesting to observe in conclusion that many of our studies show that even these reactions probably occur chiefly through heterogeneous processes. This new field of study again emphasizes the importance of kinetics in modern chemistry.

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Electrolytic Oxidation of Hydrochloric Acid to Perchloric Acid[1,2]

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Perchloric acid is not easy to prepare, hence the price is high. The uses of this very unusual and important acid and its salts are greatly limited by this high cost. Electrolysis of hydrochloric acid, a comparatively cheap starting material, was found by early experimenters (1) (2) to produce some perchloric acid but no yields were published. Later more extensive experiments (3) reported the electrolytic formation of perchloric acid but again no yields were published. The most complete and successful experiments (5) reported the making of small commercial quantities of perchloric acid by electrolysis of hydrochloric acid. The operation of this process was very soon superseded by chemical methods which have since become quite important developments. The best conditions are a high current density .1 to .2 amp./sq. cm., a low temperature of 20° and a very dilute solution of hydrochloric acid. Only dilute solutions of perchloric acid could be obtained which required much expensive evaporation for making a final product of 50%.

The idea being tested in these experiments was that the optimum condition for producing ozone by electrolysis would be the best conditions for the oxidation of hydrochloric acid to perchloric acid. Previous experiments had not reached these conditions because very dilute hydrochloric acid solutions are not best for ozone making. Sulfuric acid of maximum conductivity is a good electrolyte for ozone production. Therefore small concentrations of hydrochloric acid in sulfuric acid were electrolyzed at high current densities and low temperatures with good material yields. Sulfuric acid was quite satisfactory for experiments since it did not interfere with any of the titrations for determination of chloride, chlorate, and perchlorate.

Of course pure perchloric acid could not economically be separated from these solutions containing so much sulfuric acid. However, industrially, low concentrations of hydrochloric acid in concentrated perchloric acid would give the ozone conditions. Each day a quantity of the acid equal to the amount of hydrochloric oxidized could be taken from the cell. No experiments were made with the electrolysis in strong perchloric acid due to the great difficulty in accurately determining the small quantities of perchloric acid produced by the oxidation in the presence of the large amounts of perchloric acid already present.

Apparatus and Method of Experimenting

Platinum wires wrapped around glass coils for cooling with running water, served as anodes and cathodes. Beakers of 400 cc. capacity standing in cold running water served as electrolysing vessels. Temperatures

1. Condensed from a thesis for the A.M. Degree at Indiana University by Mr. Donald Ballman. He is now in the Sales Department of the Dow Chemical Company, Midland, Michigan.

2. Contribution No. 630 from the Department of Chemistry.

lower than 30° could not be attained without ice since these experiments were run during summer weather.

Methods of Analysis

Chloride was determined by a direct application of Volhard's method. Chlorate was determined by a titration with excess ferrous sulfate and a back titration with potassium permanganate. Finally a measured quantity of the electrolyte was neutralized with sodium hydroxide, evaporated to dryness, mixed with sodium carbonate and a trace of potassium permanganate and fused. This changed both chlorate and perchlorate into chloride. A Volhard determination on this residue gave total chloride. From these data perchloric acid was calculated.

A series of experiments showed that acid concentration of 1:5 was best.

Yields were highest at about .2 amp/sq. cm.

The percent conversion was highest at low concentrations of the hydrochloric acid whereby loss of free chlorine was minimized. The best yield in any experiment was 48% for .06 N. HCl.

In some long runs the data and results are:

Two beakers in series at 6 amp. with 6 inches of platinum wire each for both anode and cathode were run for 35 days, with tap water cooling (about 30°). Each day 2° ml. of 50% HCl were added to each. It would have been better if this acid could have been added continuously rather than in one daily batch. One beaker started with pure water, the other with 1:5 sulfuric acid. At the end, the experiment using sulfuric acid contained 96 grams of perchloric acid and the one with pure water contained 98.8 gms. It is thought that the lower final yield with water was due to a very low yield at the start until the concentration of perchloric acid built up sufficiently for ozone conditions. These results calculated out to a material yield of 12.4 percent based on the hydrochloric acid used. Loss of free chlorine was the cause of the low yields. The higher yields reported used much less conc. of hydrochloric acid and lower currents.

Yields were a little higher at 20° than at 30° but not enough better to warrant the trouble of operation at the lower temperature.

Conclusions

While perchloric acid can be made by electrolysis of hydrochloric acid at high currents the slowness of the process and the lower material yield when attempts were made to speed the action and the low current efficiencies indicate possibility of an economical way to prepare perchloric acid.

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Aluminum Bromide-Hydrocarbon Complexes

HERBERT C. BROWN and WILLIAM C. FRITH, Purdue University[1]

There is considerable interest in developing a satisfactory mechanism for the Friedel-Crafts reaction. Such mechanisms as have been proposed are relatively vague as to the precise function of the catalyst and the catalyst complexes in the reaction mechanism. An understanding of these substances is essential before their role in the reaction can be understood. In order to gain insight into the exact nature and function of these catalysts and catalyst complexes, a study has been undertaken of a typical Friedel-Crafts catalyst, aluminum bromide, and its interaction with aromatic hydrocarbons in the presence and absence of hydrogen bromide.

There is ample evidence that aluminum bromide does react with benzene and other aromatics. Thus, Ulich (1) obtained a dipole moment of 4·9D for benzene solutions of aluminum bromide, and later Plotnikov (2) confirmed this, but found that for high concentrations, the dipole moment decreased to zero. This was attributed to dimerization of $AlBr_3$ at higher concentrations, and later workers (3, 6) have since shown that aluminum bromide is largely dimeric in hydrocarbon solutions.

Complexes have been isolated by a number of workers, notably Plotnikov (4), Eley (5) and Van Dyke (6), all of whom obtained the hydrocarbon: halide ratio of $1Ar:1AlBr_3$, the two former formulating the complex as $Ar:AlBr_3$ and the latter as $Ar_2{\cdot}Al_2Br_6$ to account for the dimeric nature of halide in such solutions.

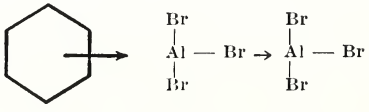
Vapor-pressure-composition studies have failed to confirm these earlier results, a complex of empirical formula $Ar:Al_2Br_6$ separating out at high concentrations (7). Molecular weight determinations using a vapor pressure lowering technique have shown that in solution at least two species occur, probably $Ar:AlBr_3$ and $Ar:Al_2Br_6$, in equilibria:

$$Ar + Al_2Br_6 \rightleftarrows Ar{\cdot}Al_2Br_6$$

$$Ar{\cdot}Al_2Br_6 + Ar \rightleftarrows 2Ar{\cdot}AlBr_3$$

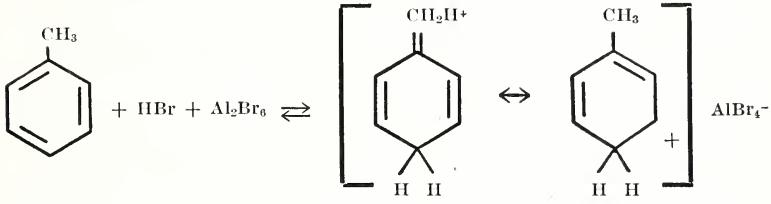
Such equilibria would largely account for the change in dipole moment with concentration, removal of benzene decreasing the concentration of complex, with formation of dimeric Al_2Br_6 which would have no dipole moment.

The structure of the complex has not been confirmed, but it is believed to be a π bonded molecule, the π electrons of the benzene ring donating to a vacant orbital on the acceptor aluminum atom.



1. Acknowledgement—The authors are indebted to the Atomic Energy Commission for financial support of this work.

In the presence of hydrogen halide, aluminum halides form much different complexes with aromatic hydrocarbons. These are the highly colored (often red) oils which are usually observed during Friedel-Crafts reactions. They have attracted the attention of a large number of workers (8) and have been variously formulated as $AlBr_3 \cdot 3Ar$, $HBr \cdot Al_2Br_6 \cdot Ar$, $HBr \cdot Al_2Br_6 \cdot 2Ar$ and others involving various ratios of hydrogen bromide, aluminum bromide and aromatic. It has been shown that these complexes, which are ionic, may be formulated as $ArH^+AlX_4^-$ and $ArH^+Al_2X_7^-$.



3 equivalent forms.

Such complexes, in which the acceptor atoms (in this case a proton) is localized on a particular atom of the benzene ring, are described as σ complexes, in contrast to the previously described π complexes (9).

It is unlikely that π complexes participate to any extent in the Friedel-Crafts reaction, but σ complexes probably play a very important role. It has been proposed that the high solubility of aluminum halides in these Friedel-Crafts complexes is due to the formation of a series of higher complexes of this kind, with the general formula $[ArH]^+[rAlX_4]^-$. In other words, that aluminum halides dissolve in these liquid carbonium ion salts just as sulphur trioxide dissolves in sulphuric acid to form a series of higher acids.

H_2SO_4, $H_2S_2O_7$, $H_2S_3O_{10}$, $H_2S_4O_{13}$ etc.
$ArH^+AlX_4^-$, $ArH^+Al_2X_7^-$, $ArH^+Al_3X_{10}^-$, $ArH^+Al_4X_{13}$ etc.

It is suggested that these complexes play an important role in those Friedel-Crafts reactions involving carbonium ions by furnishing a highly polar medium in which ionic intermediates may form and react.

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ENTOMOLOGY

Chairman: M. Curtis Wilson, Purdue University

Paul T. Ulman, Noblesville, was elected chairman for 1954

ABSTRACT

Is the potato flea beetle becoming resistant to DDT? George E. Gould, Purdue University, and L. L. McCrosky, Richard Gumz Farms, North Judson.—A large population of flea beetles and extensive foliage injury was observed during 1951 in potato fields receiving eight to twelve applications of the standard DDT spray. In the early part of 1952 season potato fields were checked carefully and again applications of DDT applied at weekly intervals failed to check the beetles. Many commercial growers substituted one of the new organic phosphate compounds in order to clean out the beetles. During 1953 experimental plots were laid out in a commercial field of potatoes grown on a muck (peat) soil to determine if flea beetles could be checked by various strengths of DDT and by other insecticides. The efficiency of the various treatments were determined by counts of foliage injury after the third and sixth applications. Dieldrin at ¾ pounds actual chemical per acre per application gave the best protection, followed by heptachlor at the same dosage and DDT at 2 pounds per acre. The schedule of spraying followed by some growers of using DDT at 1¼ pounds for applications 1, 2, 4 and 5 and the phosphate insecticide on 3 and 6 had the highest injury count, as apparently the latter material gave a quick but temporary relief from flea beetle feeding.

The Role of Insect Control Measures Involving Farm Practices in a Chemical Era

M. Curtis Wilson, Purdue University

Introduction

The writer has selected a subject for review which is of timely interest to all of us who are associated with the science of entomology because entomology as an applied science is evolving at a rapid rate, more rapid since World War II than at any previous time. New methods of control procedures are developing, some of which are remarkable for their effectiveness; others are being developed without thought to overall effects because it may be easiest to follow the path of least resistance.

The prolonged over emphasis of any procedure may be analogous to orthogenesis phenomina of evolution. The effects of orthogenesis both good and bad are clearly understood by biologists and it is the responsibility of entomologists to understand and promote the former and their obligation to mankind to prevent the latter in dealing with their science.

There is little doubt in the minds of most entomologists that the applied science is evolving almost in a straight line in the direction of chemical control of insects. In the years following World War II with the development of tremendous numbers of new organic insecticides the science of applied entomology has entered a new phase, the chemical period. The impetus of industry and the excellent results obtained with many of these new chemicals have caused this phase to evolve with alarming speed.

Entomologists are aware of some of the problems that have arisen since organic insecticides have come into use; problems of contamination, problems such as the development of hardy strains of insects resistant to insecticides as well as the development of serious insect problems because the insecticide kills predators and parasites, but not the host. There are also the problems that develop where there is no evidence that the natural enemies are killed, but the host population build-up occurs, nevertheless. Under such conditions it appears that the insecticide may have an attracting effect or other influence beneficial to the development of an insect population.

A philosophy of general chemical control does not take into consideration the ease with which a simple farm practice can often be employed to prevent a problem before it develops.

This discussion will be confined to the insect problems of field crops. Perhaps at this point a definition should be given of what is meant by a good crop practice to be utilized in insect control.

"A sound farm practice for insect control is a method of *preventing* insect damage to a crop by providing conditions unfavorable to insect development in such a way as to allow economic production of that crop and at the same time be adapted to the best agronomic practices."

Using this definition, a rotation to control insects where it is economically and agronomically feasible, is a sound farm practice. However,

this same practice under other conditions may be unsound. The use of an insecticide in place of a rotation may become a good practice if the use of that insecticide makes it possible for the farmer to grow a crop several years on the same land where that is economically and agronomically the most advantageous thing to do.

The coming of the chemical era with the development of highly effective organic insecticides has replaced many farm practice recommendations that had been in effect for many years. This is not due entirely to the discovery of effective chemicals and equipment for application. It is also due to such new developments as hybrid corn, improved varieties and changes in fertility and rotation programs in crop production. Practices which were considered sound a few years ago are not always considered the best today. It is important to remember that the most sound agronomic practices which enable maximum production with least effort and expense will always be basic in insect control. The entomologist should never lose sight of the crop, for his objective is to successfully produce that crop—*not to control the insect!* If he can produce a sturdy plant able to sustain insect injury by increasing soil fertility or by breeding a hardy hybrid, why use an insecticide or a laborious mechanical method? It may be possible to grow the crop and feed the insects too, when the plants are hardy and in this way limit insecticidal use where possible to unusually heavy outbreaks.

The use of farm practices as a means of insect control has been applied most extensively to field crops, or crops grown in large acreages. Some of the more important of these practices will be discussed with an attempt to evaluate them and show where a revision of some of these recommendations has been, or may be, necessary because of changes in crop production and newer materials and equipment available for insect control.

Delayed Planting to Prevent Insect Outbreaks

Many insect problems have been approached by a study of planting dates in order to find dates when a crop might be planted to avoid insect attack. Since some insects attack a crop only in a certain stage of plant growth, attempts have been made to prevent synchronization of the insect with the crop by delaying planting. There is considerable merit to this principle where it can be applied. Two outstanding examples of the successful use of this practice are the recommendations for corn borer and Hessian fly control which have been practiced for many years.

In the case of the Hessian fly it was found that infestation could be prevented by delaying the planting of wheat until the flight of flies had passed. For years, delayed planting of wheat has been the standard recommendation for control of this insect.

In recent years, two things have occurred which are influencing control of the Hessian fly. First, crop rotations have changed in most of Indiana so that wheat follows either soybeans or corn. This means that wheat of necessity cannot be planted until after the beans or corn have matured which is at least one week to ten days after the fly free date. This agronomic practice has been of considerable significance in reducing

Hessian fly outbreaks. Since wheat is normally planted considerably later than the fly free dates, the threat of this insect in the fall to new seeded wheat has been lessened.

The second factor to affect Hessian fly control in recent years is the use of the combine. In combining a wheat field, considerable grain lost in the field is the source of a great deal of volunteer wheat. This volunteer wheat is ideal for the development of a spring brood and under present agronomic practices this brood from volunteer wheat is the real threat to Indiana wheat. A cleanup program that would involve plowing under the stubble in the fall is not possible since clovers and grasses are seeded in most of the wheat to provide pasture, hay, and soil improvement crops the following year.

It appears that the solution of this problem will be in the use of varieties of wheat resistant to Hessian fly. Fortunately, the Bureau of Entomology and Plant Quarantine has made a great deal of progress in this line of research. Varieties suitable for Indiana conditions are now being multiplied for release.

Another problem which, like the Hessian fly, has been successfully controlled through the use of planting dates is the corn borer. Most entomologists are aware of the outstanding research of the late George Fitch in Indiana which showed that corn had to reach a certain height before it was attractive to the corn borer moth for oviposition. This research became fundamental in all future corn borer recommendations since it was found that the ideal planting dates for corn borer control coincided with the dates at which highest yields were obtained.

Aside from delayed planting of corn as a corn borer control measure, hybrid corn was found to be quite tolerant to the insect and the use of adapted hybrids and delayed planting became fundamental in corn borer control.

The emergence of a second brood created a new problem in corn borer control for corn planted after the recommended date was very susceptible to the second brood. Present recommendations attempt to select planting dates that will escape severe infestation of both broods. This is difficult to accomplish since it allows a relatively short period in which to plant and the weather conditions do not always make this possible.

Production of specialized crops, development of hybrid corn, and changing views in crop production make it necessary to allow for exceptions. There are three exceptions to the recommendation of delayed planting for corn borer control. These exceptions are made possible because insecticides are available in which complete control can be obtained if treatments are properly timed. The exceptions are for the farmer who grows early market sweet corn, the hybrid seed producer, and the farmer who has very droughty soils. The early market sweet corn grower of necessity has to use insecticides since his market demands early planting which produces corn in a highly susceptible stage at the time the moths are flying.

The hybrid seed producer deals with a crop of very high value. His corn must be mature enough to dry and shell before danger of freezing. Freezing kills germination and the seed cannot pass certification. Because

of this some growers have had severe losses and the trend is to plant as early in May as possible. If bad weather should prevail at May 20, later planted corn is almost certain to suffer some loss from frost.

Many agronomists now believe that an early corn hybrid should be planted early on droughty soils. Their theory is that usually the corn can be made before drought occurs without loss in yield. This theory has been evident in Indiana during the last two years in early planted corn fields.

Crop Rotations to Prevent Insect Outbreaks

Aside from delayed planting, many other types of farm practices have been developed to prevent or control insect outbreaks. Of these, crop rotation is one of the most important. This method has been employed primarily in controlling insects of the soil. By simple rotation of crops, many pests have been brought under complete control. However, it is in this line that a great deal of research needs to be extended. Farm practices involving the rotation of crops to control insects were excellent for their time, but we now have new and varied needs which call for many exceptions to the rule. Research in the production of field crops has progressed rapidly, and insect control measures must keep pace. A procedure that is a good farm practice from the standpoint of insect control alone may not be a good recommendation.

Agronomic research and practice shows that certain rotations recommended in insect control may not be advantageous for the following reasons:

1. There is no advantage from rotating sod crops on hilly land. Rotation of hilly land causes serious erosion problems. There is a trend to seed hilly land to continuous pasture crops.
2. There is a trend to plant continuous corn on heavy loam soils where the fields are flat. If properly fertilized, the agronomists say there is no disadvantage to this procedure. In some cases, problems of soil structure may arise, but studies indicate that a soil improving legume may be planted with the corn. With this type of farming, erosion is reduced and cropping is confined to the most productive soil.
3. A new type of rotation is to go directly from corn to hay without seeding a small grain. This is accomplished by planting the corn rows wider and seeding legumes and grass between the rows.
4. Pure stands of alfalfa or clover are disappearing. It has been found that mixtures of grass and clover or alfalfa are preferable to either the grass or legume alone. Mixtures control weeds since grasses are easily established. Grasses tend to produce a sod which helps to bring legumes through the winter. For pasture, grass is preferred for cattle and sheep. The legume produces nitrogen for the grass and is feed for livestock during dry weather.
5. Because of high water from floods, rotations cannot be followed in the river bottomlands and this land is largely planted to continuous corn.

These changes in views on crop rotation are not mere agronomic theories. It is true that some are in the research stage, but farmers can be found in Indiana who are applying each of these new concepts.

How will these new concepts or trends affect insect control? Already they are having tremendous effects in increased outbreaks of white grubs, wireworms, northern corn root worm, grape collaspis, and billbugs. Others could be mentioned. With favorable habitats many of these insects have been increasing gradually until in 1953 when environmental factors were near optimum to the development of insects, more serious economic insect problems of field crops, particularly of corn, occurred than ever experienced in Indiana.

Fortunately, in 1953 there was an abundance of insecticides developed since World War II that could be applied in such an emergency. Otherwise, there would have been crop failures.

These facts corroborate the necessity of research to develop new methods of insect control that will fit in with newer agronomic practices. The entomologist must realize that insects are only one factor in the complex of crop production. Therefore, when agronomic procedures change, if he is thinking in terms of the crop instead of the insect, he will initiate studies for new control methods which are adaptable to the change in cropping practices.

Undesirable Farm Practices Used to Prevent Insect Outbreaks

In the past because other methods were not available for the control of injurious insects, methods involving farm practice were frequently advocated which we now know to be undesirable. These include such practices as the planting of a crop distant from another, elimination of crops during outbreak years, and use of trap crops, cleanup involving the burning of crop residues, fall plowing on certain soils, and delayed harvesting of one crop to prevent infestation of the next.

Few farmers can afford to utilize a recommendation that requires them to plant a crop distant from another, nor can they usually eliminate certain crops in infestation years. Such a procedure interferes with rotations and the general farm program.

Economically, the use of trap crops to control insects may be costly to the farmer. For the control of certain insects it requires a great deal of additional labor to plant a crop twice, a procedure which is seldom feasible. To control wireworms or rootworms by this method it is necessary to plant the entire field to the trap crop prior to planting the primary crop. Purdue economists estimate that this procedure would cost from $3.50 to $4.00 per acre for seed and planting. Since two to three weeks would elapse following the planting of the trap crop before seeding, the risk of a hard seed bed for the primary crop is involved.

To control some insects such as the corn borer with trap crops, it is possible to plant only certain areas to the trap crop, seeding the corn early so that it is highly attractive to the moths. However, this procedure may restrict profitable utilization of all of the field.

Cleanup programs involving the burning of crop residues are a costly waste of soil organic matter and would never be advised today except as a last resort in a severe emergency.

Fall plowing of easily eroded soils is a poor practice from the standpoint of conservation.

Delayed harvesting of one crop to prevent infestation of another may seriously affect the quality of one of the crops. This is evidenced in particular by the old recommendation for control of the potato leafhopper on alfalfa. It was recommended that harvest of the first alfalfa cutting be delayed until the middle of June until the leafhoppers had layed their eggs. In this way the eggs would be removed with the first crop and the second would not be heavily infested. However, there is an optimum time for cutting alfalfa and a delay in harvest means a sacrifice in the nutritive value of the crop.

In this discussion comment has been, in most cases, confined to those farm practices which continue to be dominant in insect control. It has been shown that some recommended practices are out of date and that changes in agronomic practice are causing some insect problems to become more prominent. Simultaneously, insecticides have been synthesized and spray equipment developed which have been, under conditions of high farm prices since World War II, economical to use. It is obvious that we have entered a chemical era and the question arises, "What role will insect control measures involving farm practices have in a chemical control era?"

Outlook for the Utilization of Farm Cultural Practices in Insect Control

The farm practice as applied to insect control is not a thing of the past; on the contrary, it is foreseen that it may arise to new importance following research in experiment stations. We are now in a chemical period largely because of high farm economy, availability of effective chemicals and spray equipment, and the fact that farm practices for insect control adaptable to new agronomic trends are still in a stage of development.

Changes in agronomic trends may make it more difficult to control some insects, but it is foreseen that these same changes may make the control of other insects easier. For example, let us consider the chinch bug. For years farmers have been fighting the chinch bug with barriers, chemicals, etc. in outbreak years. Many of the new organic insecticides have been tried but results have been erratic. Control has ranged from 0 to 100 percent.

It has been known for a long time that the chinch bug is a sun loving insect and that shade is unfavorable to its development. A study of the history of the chinch bug will show that wheat fields are infested much less today by chinch bugs than they were twenty years ago. A study of wheat production in recent years shows that the tendency has been to grow legumes such as sweetclover in the wheat. Likewise, modern improved varieties of wheat and high applications of fertilizer have been used. These factors have produced dense stands which are heavily shaded and unfavorable to chinch bugs. Thus, the chinch bug is less of a problem than it used to be. With this thought in mind, it is foreseen that the

chinch bug problem may be lessened if the agronomists turn to a practice of growing legumes with corn which will shade the base of the corn plants.

In the future, farmers will have increasingly more varieties which are tolerant and perhaps resistant to insects. The use of resistant or tolerant varieties is the most desirable method of insect control because of its simplicity and low cost. However, the breeding of resistant or tolerant varieties is a slow process as it involves many years of selection and testing of plants by plant breeders and entomologists. However, it has been shown that hybrid corn has been developed which is more tolerant to the corn borer and that wheat resistant to the Hessian fly is becoming available. The Departments of Entomology and Agronomy at the Purdue Agricultural Experiment Station are working cooperatively to develop varieties of alfalfa which will be tolerant to the meadow spittlebug and the potato leafhopper. Considerable progress has been made in these studies and it is hoped that tolerant varieties will be available within a few years.

Aside from the development of varieties tolerant to insects, studies are underway to produce greater tolerance in a crop plant by applying principles of growing a vigorous and healthy plant. It is easily understood that a healthy plant will withstand more insect damage without loss than an undernourished spindly plant.

To prevent loss in stands from infestation by the sweetclover weevil, principles that would promote accelerated growth of the plants, once the seed had germinated, were applied. It was found that by increasing soil fertility by top-dressing the soil in the spring, increased vigor could be obtained and many plants which otherwise would have been killed by the weevil could withstand the damage. Where infestations had been heavy, DDT could be applied in the same operation by combining it with the fertilizer. This protected the plants until establishment. Recent studies show that DDT can be applied in combination with liquid nitrogen. This treatment is very simple to apply and only the cost of the insecticide is involved, since the nitrogen application to small grains is a regular spring procedure in Indiana.

Plant vigor can also be increased through irrigation. Studies on Purdue experimental farms on droughty soils indicate that under irrigation, damage to alfalfa by the potato leafhopper is much less. Thus, under conditions that produce vigorous plants there is less need for chemical treatment to control insects, and when applied, dosages often can be smaller and the number of applications may be less.

Developments such as have been mentioned do not indicate the eventual elimination of insecticides. On the contrary, insecticides will continue to be used in large quantities, but the trend in general should be toward the control of outbreaks that get out of hand. In some cases, because of economics in which very small quantities of insecticide can be used at low cost without hazard, the use of insecticides should be considered good insurance and will be employed because it is a good practice. For example, when planting corn in a soil that has had any indication of wireworms, a farmer could not afford not to apply a seed treatment

which would cost only 16 to 20 cents per acre. Likewise, when grasshoppers can be killed for only 56 cents per acre, there is no incentive to mix bait, nor would there be any reason to use the frequently undesirable practice of plowing in the fall to destroy the eggs.

Conclusion

In conclusion, farm practices to control or prevent insect outbreaks are not a thing of the past, but a thing of the future in a chemical era. However, entomologists must recognize the specialization of crops and agronomic procedures which is becoming more and more pronounced. Such specialization requires control measures to fit the case. This means that the entomologist is challenged with the task of providing a variety of control measures, one of which can be utilized for each circumstance. Insects are important, let us not minimize them; but they are only a single factor in the complex production of a crop. Therefore, they should not be the limiting factor in the utilization of a soil or the production of a crop.

Research in entomology if it is to keep pace with agronomic research will produce improved methods which will incorporate the use of insecticides in sound programs where it is economically and agronomically most feasible to use them. To do this, the research entomologist cannot be a lone wolf. He must work cooperatively with the plant breeder, the soil specialist, the irrigation specialist, the plant pathologist, the soil microbiologist, and other specialists who are concerned with the production of the crop. Finding the best method of producing a crop requires cooperative team work of all specialists working on that crop. Think first, in terms of producing the crop, and as an entomologist, think secondly, in terms of controlling the insect!

Insects of Indiana in 1953

J. J. Davis, Purdue University

The 1953 season in Indiana provided variable climatic conditions, favorable to some insects and unfavorable to others; likewise favorable to some crops and unfavorable to others.

Field Crop Insects

Early in the season insects attacking crops of the grass family were unusually prominent. Of these the army worm was most prominent.

The army worm *(Pseudaletia unipuncta)* was the most widespread and abundant in my experience in Indiana, which dates back to 1911, and apparently was indirectly due to weather conditions. Army worm moths were abundant the last of April and early May and notices were sent out predicting possible abundance of army worms a month hence. It is not uncommon in Indiana to have army worm moths abundant in the early spring, but only every three or four years do the worms cause appreciable damage, because they are normally checked by parasites.

The first reports of army worm abundance were received the last week in May. From June 1-20 we were answering long distance telephone calls almost continuously regarding army worm outbreaks. The early reports all came from southern Indiana. Beginning about June 10 we began receiving reports of abundance and damage in the northern half of the state, although not as general and severe as in southern Indiana. By June 20 we were receiving reports of abundance of "eggs of army worms," which proved to be cocoons of common army worm parasites. No further trouble was experienced during 1953. Major damage was to corn, wheat and pastures.

The absence of normal parasitism will explain the outbreak, and the absence of parasites may be explained by the weather. A cool spring prevented normal development of the parasites, but the army worms, not requiring as high a temperature as parasites, continued to develop. Also vegetation was rank which favored maximum army worm egg laying. As a result, more eggs were laid than usual and the worms developed without their normal parasite checks. It was not until the worms were nearly full grown that the weather permitted the parasites to "catch up" with them and check their development.

It should be noted that insecticide dealers were very cooperative and maintained adequate supplies of needed insecticides. Likewise, county agricultural agents were alert to the situation and aided materially as did also service applicators, especially aerial applicators. It is estimated that at least $4,000,000 were saved for the farmers because of adequate service provided by county agents, insecticide dealers and service applicators.

The yellow striped army worm *(Prodenia ornithogalli)* became destructively abundant in the latter part of June in southern Indiana following the common army worm outbreak. The outbreak was not too important but alarming following the disastrous army worm outbreak.

Cutworms, especially the overflow, black, or greasy cutworm *(Agrotis ypsilon)*, as it is variously called, became a serious pest throughout the state.

The corn flea beetle *(Chaetocnema pulicaria)* was unusually abundant and destructive during the last of May and during June and in many cases called for insecticide treatment. In some areas the flea beetles continued abundant throughout the growing season. Stewart's disease, carried by the flea beetle, caused much loss to corn plantings the latter part of June.

Chinch bugs *(Blissus leucopterus)* were destructively abundant in northeastern Indiana from Wayne County northward and to a lesser extent in northwestern Indiana. Damage was not serious, but indications are that there may be a carry over which may develop a serious infestation in 1954.

The corn seed maggot *(Hylemia cilicrura)* was unusually abundant, probably due to the cold, wet spring, which prevented prompt seed germination.

Sod webworms *(Crambidae)* were abundant in many corn fields in northern Indiana.

The common stalk borer *(Papaipema nebris)* was destructive, especially to corn, during June and especially in northern Indiana.

Grasshoppers *(Melanoplus mexicanus, M. femur-rubrum,* and *M. differentialis)* were more abundant and destructive than usual, especially in the southern third of the state. In the northern half of the state they were abundant but were scattered and damage was in isolated areas. Grasshoppers were especially abundant during July and August, and especially to grass, corn, soybeans and other legumes.

In general, the European corn borer *(Pyrausta nubilalis)* was not destructively abundant although there was a noticeable increase and damage in a few localities, particularly in certain northwestern and south central counties. Practically no infestation in corn planted between May 15-30. The 1953 fall survey of overwintering borers showed an increase in borer population from 39 borers per 100 stalks in 1952 to 62 in 1953. Furthermore, the borers were in a better condition for overwinteing this fall than a year ago.

The corn earworm *(Heliothus armigera)* was unusually abundant throughout the season. Damage to early sweet corn was first observed in the Evansville area. Damage to early market tomatoes was also noted. During September infestation of canning tomatoes became so severe that a number of canneries stopped operation several weeks before normal closing.

Wireworms *(Elateridae)* continue as major pests of various crops, but especially corn and potatoes, in sandy loam soils as well as in muck. The larger growers are using soil insecticides and in general are getting good results.

Pea aphids *(Macrosiphum pisi)* were unusually abundant on clover and alfalfa during April and first half of May in the southern half of Indiana, so much so, in fact, that insecticide control was practical in many areas.

The clover leaf weevil *(Hypera punctata)* was abundant on clover, and to a lesser extent on alfalfa in early May, but apparently did not cause appreciable damage.

The clover root borer *(Hylastinus obscurus)* was exceptionally abundant in second year clover near Huntington. Counts made by R. T. Everly in one field showed 75 percent of the plants infested, averaging six borers per plant. There is reason to believe that this insect is more abundant and destructive than commonly believed.

The common spittle bug *(Philaneus leucophthalmus)* began hatching from overwintering eggs in early April and was normally abundant and destructive over the state. The more general use of insecticides on clover, as recommended, has doubtless reduced losses materially.

Bean leaf beetles *(Ceratomia trifurcata)* damaged soybeans in some localities the latter half of June.

The Japanese beetle *(Popilia japonica)* was found in conspicuous numbers in 1953 in Newton County, Indiana, and adjoining Iroquois County in Illinois. The extent of the infestation indicates that the introduction occurred at least six years ago. The insect is well established in a typical corn belt farm area and we can anticipate a rapid spread to adjacent areas, unless extermination methods are practiced and are effective. Although the Japanese beetle has been found in few numbers in many localities in the state, primarily in cities, only one previous infestation, comparable with the one reported above, has been found and that in the outskirts of South Bend.

Vegetable Garden Insects

Potato flea beetles *(Epitrix cucumeris)* were quite abundant on potatoes early in the season.

The potato leafhopper *(Empoasca fabae)* was very common on potatoes during the last half of June.

The rhubarb curculio *(Lixus concavus)* was reported from many scattered localities throughout the state.

The cabbage maggot *(Hylemia brassicae)* was a major problem throughout Indiana, attacking cabbage and other cole crops.

Fruit Insects

This has been the year of the 17-year cicada *(Magicicada septendecim)*. The adults began emerging in southern Indiana, at Orleans, May 19, and at Lafayette, May 29. It was common throughout the state but not as abundant or conspicuous in the northern half as seventeen years ago. In southern Indiana it was a severe pest of young and old fruit trees.

We were criticized by officials of the American Nurserymen's Association for reporting the anticipated cicada abundance and suggesting delay in planting fruit trees until this fall or next spring. The Association objected to our publicity on the grounds that we were hindering the sale of nursery stock. Observations subsequently made showed that our precautions and warnings were well made and that such criticism was

unwarranted. Damage for the season was notable, but more important is the fact that all attacked trees will show the damage in production losses, for years to come.

Insects of Shade Trees and Ornamentals

Bagworms *(Thyridopteryx ephemeraeformis)* are again building up to destructive numbers, after a couple of years of comparative scarcity.

The bronze birch borer *(Agrilus anxius)* was noticeably more abundant and destructive than usual, possibly due in part to drought conditions during the 1953 season, weakening the trees and making them more susceptible to attack.

The elm leaf beetle *(Galerucella xanthomelaena)* was common throughout the southern third of the state, and from reports received, much more so than usual.

The maple bladder gall, caused by a mite *(Phyllocoptes quadripedes)*, was perhaps the most common leaf gall reported, possibly because it is so conspicuous, although of little economic importance.

The flat-headed maple borer *(Chrysobothris femorata)* was reported many times from all parts of the state. Although primarily a pest of young hard maple trees, it has been reported attacking other trees including fruit and shade trees. Weakened trees and especially recently transplanted trees are especially subject to attack. Wrapping trunks of newly planted trees is becoming a common practice and will protect trees from attacks.

Household and Miscellaneous Pests

The American dog tick *(Dermacentor variabilis)* was more common than usual, according to the number of inquiries received, leading us to believe this increase might reflect in the number of cases of Rocky Mountain spotted fever. However, there seems to be no correlation between the 1953 tick abundance and spotted fever because Dr. J. D. Salisbury of the Indiana State Board of Health advises that cases reported to the Board were 14 in 1948, 9 in 1949, 8 in 1950, 4 in 1951, 2 in 1952 and 4 in 1953.

Black carpet beetles *(Attagenus piceus)* are still a major household pest, evidenced by the large number of inquiries. From reports and observations, they are far more important pests of woolens and furs than the clothes moth.

Fleas *(Ctenocephalides felis* and *Pulex irritans)* have been reported many times from all parts of the state and from both urban and rural areas.

We continue to receive many inquiries regarding bees in the walls of homes and wasp nests about homes, especially under eaves. We have prepared a mimeograph statement giving suggestions for control.

The subterranean termite *(Reticulitermes flavipes)* is an annual pest which maintains its importance from year to year. A major problem has to do with itinerate operators who move from town to town or from points outside the state. With rare exceptions their work is definitely fraudulent and costs Indiana citizens many thousands of dollars annually.

Another insect causing damage to building timbers is the powder post beetle *(Lyctus* spp.*)*. During the year many inquiries have been received, sufficient to recognize it as a problem of major importance.

Ants of various species are reported throughout the year, some disfiguring the lawn and garden and others annoying in the home. Reports are especially common in the fall when common species of ants swarm. Since they often swarm from their soil nests near foundations, they are mistaken for swarming termites. Our observations indicate that termites do not swarm in Indiana after July 1.

Invading Pests

From inquiries received there seems to be increasing annoyance from insects and mites which breed out-of-doors and enter homes in the fall of the year. They do no damage to buildings or furnishings but often become very annoying and obnoxious. The following may be included in the category of invading pests.

Box elder bugs *(Leptocoris trivittatus)* continue as an annual pest. They breed on box elder trees and in the fall, upon becoming mature, migrate about seeking shelter for the winter and in so doing enter homes where they may be annoying throughout the fall, winter and spring.

The clover mite *(Bryobia praetiosa)* again made its appearance in April and again in October, migrating into homes and becoming a conspicuous nuisance. Observations show that the majority of inquiries are from new subdivisions, where normal infestations occurred in natural vegetation, increasing with the succulent grass and clover vegetation, planted for lawns.

The strawberry root weevil *(Brachyrhinus ovatus)* is another home invader which is frequently reported.

With the increase of the elm leaf beetle *(Galerucella xanthomelaena)* in southern Indiana, increasing reports of their migration into homes as a nuisance are being received.

The willow aphid *(Melanoxantherium smithiae)* is abundant on willow every fall. They seem to do but little harm to the tree, but they have the habit of migrating to lawn furniture and into homes and when crushed cause a blood red stain.

The hackberry nipple gall psyllid *(Pachypsylla celtidis-mamma)* (Russell det.) has become an exceedingly annoying pest, getting through screens and into homes in the fall of the year. It first appeared as an invading pest just a few years ago, and this fall (1953) it has been more abundant and troublesome than at any time in the past.

Contrasts in the Orthopteran Faunas of Grassland, Forest, and Transitional Areas in Southern Indiana*

Irving J. Cantrall and Frank N. Young

The obvious fact that grassland and forest contrast sharply in physical conditions and vegetation has been recognized since prehistoric times, but the correlated contrast in faunas is less obvious today than it was before the large herbivores and predators were extirpated. In southern Indiana, an originally forested area has been largely converted into artificial prairies interspersed with woodlands. Under such conditions, when active cultivation ceases, forest plants and animals begin to reinvade the abandoned fields, but, since this process of succession is extremely slow, associations of plants similar to the tall grass prairie persist for a considerable length of time. The occurrence of such semi-natural situations presents a number of problems of interest from both the theoretical and practical point of view.

One of these problems in which the writers have been interested for many years is the relation between abundance and habitat of various species of Orthoptera. It is obvious that any disturbance in a habitat is accompanied by population fluctuations with the increase of some species and the decrease of others. The appearance of the migratory locust, *Melanoplus mexicanus* migratory phase *spretus*, following reduction of the great buffalo herds may be a classical example of this phenomenon. Similar fluctuations in populations of insects followed the clearing of the woodlands. Few of the forest insects were able to survive in the open areas, and the newly available niches were filled by forms which were originally restricted to narrow strips along streams or other special situations. Some species of grasshoppers, such as *Spharagemon bolli*, must have increased greatly in southern Indiana as the woods were cut or thinned, while others, such as *Melanoplus punctulatus griseus*, must have decreased. Unfortunately, the historical details of these processes are lost to us, but it is possible to surmise some of the probable events by examining the existing conditions.

The area selected for a study of the contrasts in the Orthoptera of a grassland area, a woodland, and the intervening ecotone is located on the property of Indiana University in Monroe County (T. 9 S., R. 1 W., Sec. 35). It is near the former site of the small pond studied by Dr. Will Scott in the early part of the century (*Proc. Indiana Acad. Sci.*, 26, 1910). The grassland is on a flat hilltop on eroded Bedford Silt Loam, while the forest is in an adjoining valley with Frederick Silt Loam predominating on the slope. The shrubby ecotone between the two lies on gently sloping areas not subjected to periodic mowing.

Collecting in the three types of situations was restricted to the same length of time on Oct. 13, 1951, Sept. 27, 1952, and Sept. 26, 1953. The collections therefore can be roughly compared quantitatively as well as

* Contribution from the Edwin S. George Reserve of the University of Michigan, and No. 540 from the Zoological Laboratories of Indiana University.

TABLE I

Distribution by Habitats of Orthoptera Collected in the Vicinity of Scott's Pond

I. CHARACTERISTIC SPECIES OF MIXED GRASS-HERBACIOUS HABITATS	GRASSLAND			ECOTONE			FOREST		
	1951	1952	1953	1951	1952	1953	1951	1952	1953
Nomotettix cristatus compressus	—	10	—	—	2	—	—	—	—
Syrbula admirabilis	—	7	47	—	3	—	—	—	—
Orphulella speciosa	—	—	1	—	—	1	—	—	—
Arphia xanthoptera	3	5	7	—	3	—	—	—	—
Chortophaga viridifasciata	—	—	1	—	—	—	—	—	—
Encoptolophus s. sordidus	25	23	30	9	11	4	—	—	—
Hippiscus rugosa	5	17	57	7	2	4	—	—	—
Dissosteira carolina	—	1	—	—	—	—	—	—	—
Trachyrhachis kiowa fusifrons	—	—	1	—	—	—	—	—	—
Melanoplus d. differentialis	—	12	5	—	—	—	—	—	—
Melanoplus f-r. femur-rubrum	16	25	41	4	7	2	—	—	—
Melanoplus m. mexicanus	5	11	8	1	2	1	—	—	—
Melanoplus keeleri luridus	2	15	2	4	10	5	—	—	—
Neoconocephalus retusus	—	—	—	—	—	1	—	—	—
Conocephalus brevipennis	19	25	1	—	16	2	—	—	—
Conocephalus nemoralis	—	1	7	—	—	8	—	—	—
Acheta assimilis	12	13	8	13	3	7	—	4	4
Nemobius f. fasciatus	2	2	5	—	—	—	—	—	—
Oecanthus nigricornis quadripunctatus	2	4	—	—	17	7	—	—	—
Oecanthus n. nigricornis	—	—	—	—	—	2	—	—	—

II. CHARACTERISTIC SPECIES OF SHRUB AND TERRESTRIAL STRATA OF OPEN WOODS AND WOODLAND BORDERS	GRASSLAND			ECOTONE			FOREST		
	1951	1952	1953	1951	1952	1953	1951	1952	1953
Stagmomantis carolina	—	—	—	—	1	—	—	1	—
Tenodera aridifolia sinensis	—	—	—	—	—	1	—	—	—
Spharagemon bolli	—	4	—	—	3	2	—	—	—

Schistocerca d. damnifica	—	—	—	—	1	2	—	—	—
Schistocerca a. americana	—	2	1	—	4	24	—	—	—
Melanoplus viridipes eurycercus	—	1	—	—	1	—	—	—	—
Amblycorypha rotundifolia	—	—	—	—	—	—	—	1	—
Nemobius maculatus	—	—	1	—	—	—	—	—	—
Oecanthus latipennis	—	—	—	—	2	4	—	—	2
Hapithus a. agitator	—	1	—	—	2	—	—	—	2

III. Characteristic Species of Tree-top, Tall Shrub, and Shrub Strata of Woods	Grassland			Ecotone			Forest		
	1951	1952	1953	1951	1952	1953	1951	1952	1953
Diapheromera femorata	—	—	—	—	—	1	4	5	3
Melanoplus punctulatus griseus	—	—	—	—	—	—	—	1	—
Microcentrum retinerve	—	—	—	—	—	—	—	—	1
Pterophylla c. camellifolia	—	—	—	—	—	—	H*	—	H*
Oecanthus angustipennis	—	—	—	—	—	4	5	4	—

IV. Characteristic Species of the Terrestrial Stratum of Woods	Grassland			Ecotone			Forest		
	1951	1952	1953	1951	1952	1953	1951	1952	1953
Parcoblatta sp., juveniles	—	—	—	—	—	—	7	7	1
Ceuthophilus sp., juveniles	—	—	—	—	—	—	5	6	3

V. Erratics—Characteristic of Habitats Not Well Represented in the Area	Grassland			Ecotone			Forest		
	1951	1952	1953	1951	1952	1953	1951	1952	1953
Tetrix granulata	—	—	—	—	—	—	1	1	—
Tettigidea lateralis parvipennis	1	1	1	—	6	—	—	1	1
Dichromorpha viridis	—	1	1	—	—	—	—	—	—
Scudderia texensis	—	—	—	—	2	—	—	—	—
Scudderia f. furcata	—	1	—	—	1	1	—	1	2
Orchelimum vulgare	—	—	—	—	1	—	—	—	—
Nemobius c. carolinus	—	—	—	—	2	—	—	—	1

* Song heard.

qualitatively. The forest collections are probably the least comparable of the three since they represent largely the ground and lower shrub and tree-trunk strata; the arboreal fauna being poorly represented.

The contrasts in the physical conditions in the three situations are very marked. The open areas have a higher evaporation rate and greater fluctuations in diurnal temperatures. Decided differences in soil moisture are evident. These varying physical factors are reflected in differences in vegetation. Both the open grassland and the ecotone show patches of very early stages in old-field succession with lichens and mosses being the principal plants.

The grassland has been prevented from succeeding to second-growth woodland by frequent mowing, but it has not been plowed or pastured for many years. In the area where collections of Orthoptera were made the principal grass is *Aristida oligantha*. This is interspersed with clumps or patches of *Andropogon virginicus, Poa compressa, Eragrostis sp., Digitaria saguinalis,* and *Phleum pratense.* Some *Danthonia spicata, Triodia flava,* and a single plant of *Panicum sp.* were also noted. The relative abundance of these forms changed somewhat over the three-year period. The principal herbs are species of *Solidago, Aster, Lespedeza* and *Plantago* together with *Acalypha sp., Achillea millefolium, Antennaria sp., Chrysanthemum leucanthemum,* and *Ambrosia elatior.* No small trees or shrubs were noted in the area in which collections were made, but seedlings of elms and other trees are present wherever protected from mowing. The ground cover is nowhere very dense, and the only shade is that provided by the grasses and herbs themselves. Lichens and mosses occur on numerous small bare spots, and a large erosion gulley with bare, steep banks transects the area. This gulley has grown progressively larger and longer over the period of the study.

The ecotonal zone, between the woods and the mowed field, consists of an old-field succeeding to second-growth woodland. The grasses noted here are principally clumps of *Andropogon virginica* intermingled with scattered patches of *Poa compressa, Triodia flava,* and a few others. Herbs are principally species of *Plantago, Euphorbia, Solidago, Desmodium* and *Vernonia* with scattered individuals of *Solanum sp., Hieracium sp., Aster spp.,* and *Antennaria sp.* Small shrubs of *Rhus glabra* and *Rubus sp.* are fairly numerous. Transgressives include seedlings of *Liriodendron, Prunus, Crataegus,* and *Ulmus* species. Small trees are moderately abundant, but do not form a canopy. They consist primarily of *Cercis canadensis, Ulmus americana, Prunus sp.,* and *Acer saccharum.* A single small *Acer saccharinum* was also noted. Near the woods where collections were not made there are some sycamores and oaks.

The cut-over and second-growth woodland varies from relatively dense and undisturbed to very sparse on the steeper slopes. The composition varies from place to place. Some areas approach the mixed mesophytic climax forest, while others are more hygric or xeric depending upon their position on the slopes of the valley. The canopy is complete over most of the area immediately adjacent to the grassland studied, and except for some places along the stream the ground is shaded and covered with a mat of decaying leaves. The principal trees present are *Acer sac-*

charum, Fagus grandifolia, and *Liriodendron tulipifera.* On most of the middle slopes beeches and tulip poplars are scattered among sugar maples six to eight inches in diameter. Oaks and hickories are relatively scarce, and occur mostly on the upper slopes of the valley. *Juglans nigra* and *Ulmus americana* are common along the stream bottom, but many of the larger elms have died for some unknown reason. No *Castanea dentata* seems to have occurred in this area. The shrub and small tree layers are poorly developed, except in a few restricted areas where *Asimina triloba* forms dense stands. *Cercis canadensis* and a few *Cornus florida* occur in scattered sites. *Rhus radicans* occurs as a low shrub on some of the slopes, and grows as a vine on trees along the stream. The herb layer is rather rich in spring flowers, but in summer and fall a very few clumps of grass *Elymus sp.,* and sedges, *Carex sp.,* are the only low plants to be seen except in sunny areas along the stream.

Mr. Dale M. Smith of the botany department of Indiana University kindly determined the grasses and checked the other plant determinations.

Collections of Orthoptera were made from the three habitats in the fall of three consecutive years. Weather conditions were similar for each year. The collecting dates were all before the first frost, and in each case followed a prolonged period of late summer and early fall drought. Drought conditions in the glassland were most evident in 1953.

The most precise quantitative data, of the type here presented, cannot be meaningful unless an analysis of the correlation of the animals with the environment under consideration is made in terms of the animals themselves. Less precise data can give much information when so considered. The Orthoptera listed in Table I are grouped not only with relation to those habitats wherein they were found but also with regard to years of study of the behavior and habits of these insects. An inspection of the table will indicate that this treatment is justified and that without it the correlation of animal to habitat would be less real.

Correlated with an animal's ecological valence, vagility and its reaction to stimuli is the degree of occupancy of that species of environment which, for that species, represents submarginal conditions. This is well demonstrated in Section I of the table. The six most abundant forms have flooded out of the grassland and into the ecotone; occupying those portions of the ecotone which are small versions of their characteristic habitat. These six orthopterans are wide-ranging, quite plastic species. It will be noted that *Conocephalus brevipennis,* although optimum conditions for the insect require more moisture than is to be found in the grassland, is, comparatively speaking, a common insect in this environment. The only orthopteran which occurs in all three areas is *Acheta assimilis.* Recent work has shown that this "species," as now known, is very probably a complex of forms, the limits of which are now unknown.

The ecotone represents a combination of a variety of micro-environments and, for this reason, those forms listed in Section II are found in the grassland as well as the woodland. However, it will be noted that they occur most abundantly in the ecotone. Correlation of species to habitat in Sections III and IV is striking.

The orthopterans listed in Section V are insects of the wet-terrestrial stratum and of moist meadow environments and in 1951 and 1952 were undoubtedly erratics from the vicinity of Scott's Pond. The pond was filled during the winter of 1952-53. Nineteen fifty-three records, in all probability, represent remnants of dying populations.

Of the forty-two forms here listed, only two can be called prairie elements. *Orphulella speciosa* and *Trachyrhachis kiowa fuscifrons* are prairie species and now, owing to the clearing of woodlands, are possibly more widespread in Indiana. However, since both grasshoppers are open field forms and because of the pressure of agricultural activities they probably have not been able to invade newly available habitat as effectively as those species which occupy the open, shrubby growths of woodland margins.

One species, *Tenodera aridifolia sinensis*, is an established advent. The remaining forms are distributed over portions of the eastern United States or all of the United States in such a manner as to leave little doubt that they were present in southern Indiana before any disturbances made by man.

The effect of man's activities upon the orthopteran fauna of southern Indiana is undoubtedly one of change in frequency and abundance of those species present prior to his coming rather than gross changes in the faunal composition owing to invasion and establishment of prairie species upon newly created prairie-like environments.

A Modified Berlese Funnel

Eliot C. Williams, Jr., Wabash College, and Roger O. Drummond,
Wabash College and the University of Maryland

A standard piece of collecting equipment in use by many entomologists is the Berlese funnel (Berlese, 1). This is a device for sorting or separating small organisms from the vegetable debris in which they live. It consists of a metal or cloth funnel with a screen near the upper portion of the funnel upon which the material to be treated is placed. At the lower end of the funnel is fastened a jar or vial. Heat is applied over the material and as desiccation occurs the animals move to the lower portions of the debris, eventually dropping through the screen at the bottom of the debris and falling to the collecting jar at the small end of the funnel. The original funnel used a specially designed water jacket as the heat source and many modifications of the basic apparatus have been made (Peterson, 2; Zinn, 3). In general, the current practice is to use an electric light bulb as the heat source.

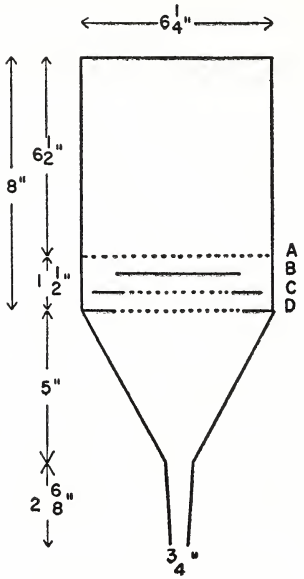
The senior author has made extensive use of the Berlese funnel in the quantitative analysis of populations living in the leaf litter of the forest floor (Williams, 4). In all of these studies an ever-present problem has been the relatively large amount of extraneous debris which falls into the collecting jar along with the animals. The term berlesate seems to be quite appropriate for the material thus collected. The debris in the berlesate presents a problem in sorting the many microscopic forms which are found in this type of collection. It greatly increases the time necessary for sorting.

In the course of an analysis of the fauna of tree holes, the authors found that the amount of debris in the berlesate was greater than that in most surface litter collections. A method of cutting down on the amount of debris without impairing the efficiency of the funnel was obviously desirable. Since the problem was a quantitative one it was necessary to insure a maximum recovery of animals with a minimum of debris.

After a series of experimental modifications was made, the one described below was found to be a very satisfactory solution to the problem. The essential feature of the system is a series of coarse and fine screens so arranged as a series of baffles that most of the debris is caught before it reaches the collecting jar, yet the organisms can readily move to lower levels of the funnel in their negative response to the desiccating power of the light bulb. The resulting berlesate is remarkably free of debris, in some cases almost a pure sample of animals.

Figure 1 shows the construction of the funnel. The legend for the figure gives the necessary data as to dimensions, size of screening, and construction details.

This system of screens can be adapted for any size funnel and the number of baffles increased for a larger funnel. We use two sizes of funnels, the one figured and one twelve inches in diameter. In each case the effectiveness of the baffle arrangement is excellent.



A MODIFIED BERLESE FUNNEL

Figure 1. Sectional view of modified Berlese funnel with screen baffles in place.

The solid lines in the screen baffles (A, B, C, and D) are 1/16" mesh window screening and the broken lines indicate ¼" mesh hardware cloth.

Screen A is 6¼" in diameter.

Screen B is 4" in diameter.

Screen C is 5½" in diameter with a center opening 3½" in diameter.

Screen D is 6¼" in diameter with a center opening 4¼" in diameter.

The screens are reinforced at the edges with 3/16" wire, soldered in place.

Screen A is removable, resting on three L-shaped flanges soldered to the side of the funnel.

Screens B, C, and the center portion of D are a removable unit. Three sheet metal legs, ½" high, soldered to the screens separate each level. This unit rests on the outer ledge of fine mesh screen of level D, which is soldered to the side of the funnel. The center portion of D is slightly larger than the opening so that the unit rests on the ledge of fine mesh screen.

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Color Variation in Some Common Species of Bumble Bees (Hymenoptera, Bombidae)

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Introduction

Since the coloration of the pile of bumble bees is of such importance in the separation of species it seems well to note any deviation in color pattern from that which is regarded as typical. Some species have a wide variation of color pattern and when such variations are of more or less common occurrence they have been described as "color variants." Other species are remarkably stable in their coloration and it is mainly with these species in which the color pattern seldom varies that this article deals. These variations are for the most part discontinuous colorations, usually of a different color, and not an overlapping or encroachment of the pile of one portion onto that of another portion. All of the specimens reported in this paper are in the collection of the author unless otherwise noted.

Variant Individuals

Bombus (Bombias) auricomus (Robertson).—On May 15, 1952, a queen of this species was taken on rose acacia by the author at West Lafayette, Indiana. The specimen has a broad apical fringe of yellow pile on the fourth abdominal tergite, the yellow color of the fringe being considerably lighter than the yellow pile present on the second and third abdominal tergites. It is very common for individuals of *B. auricomus* to have the first abdominal tergite covered with yellow pile in varying proportions but seemingly quite uncommon for any of the abdominal tergites after the third to bear other than black pile, especially if this coloration is discontinuous. Males of the species rarely have some yellow on the fourth abdominal tergite according to Franklin (1).

Bombus (Separatobombus) griseocollis (DeGeer).—A color condition frequently met with in examining bumble bees is the presence of a small tuft of white, yellow or ferruginous pile located conspicuously on some one of the abdominal tergites which typically is covered with black pile. This type of aberrant coloration has been termed "flecking" by the author simply as a matter of convenience in describing it.

On May 20, 1953, a queen of *B. griseocollis* was collected by the author as she visited rose acacia. On the extreme left side of the second abdominal tergite is a small, but very noticeable, tuft of white pile.

Bombus (Pratobombus) bimaculatus Cresson.—Two queens, both from the Purdue Student Collection and labelled Lafayette, Indiana, differ markedly in coloration from the typical species and its described color variants. One queen has the yellow pile of the second abdominal tergite extending to the apical margin on the left side only; the other queen has an apical median patch of white pile on the second abdominal tergite, discontinuous with the basal median patch of yellow pile on that tergite.

Bombus (Pratobombus) impatiens Cresson.—*Bombus impatiens* might be considered somewhat unique in that it is one of the very few species in the subgenus *Pratobombus* not to have described color variants. The yellow pile of the abdomen is usually confined to the first tergite in both sexes; however, it is not too uncommon for the yellow pile of the first abdominal tergite to overlap onto the second. In a few instances, the yellow pile on the second tergite occupies fully as much of this tergite as it does in certain specimens of *Bombus bimaculatus*. When this is the case students often confuse the two species. The two species are readily separated by the difference in the length of the malar space, differences in the labrum, etc., but these characters are seldom listed in the available keys to the species. A number of specimens of *B. impatiens* with yellow pile on the second abdominal tergite have been taken in Indiana.

A distinct color variation is noted in two queens of this species taken in West Lafayette during the spring of 1952. One individual was collected by Mr. Charles Ash, the other by an unidentified student. Both specimens have the entire right half of the second abdominal tergite covered with bright ferruginous pile. The left half of this tergite is covered with black pile in both specimens.

A male taken October 6, 1952, in West Lafayette has an apical fringe of whitish pile on the second abdominal tergite. This fringe is very broad on the right half of the tergite and includes the basal portion of the third tergite on this side. The third abdominal tergite has an apical fringe of ferruginous pile extending completely across the tergite, the extreme left portion being a white blotch continuous with the ferruginous fringe.

"Flecking" is quite common in this species, the following examples being noted:

A queen, which escaped capture (May 15, 1952), had an apical, median, ferruginous patch on the second abdominal tergite. Two other queens from the Purdue student collection exhibit this same coloration.

Two workers, one from West Lafayette, Indiana, collected by the author and the other from Hole-In-Rock (Douglas Co.), Kansas, collected by Dr. W. R. Enns, have an apical, median white patch on the second abdominal tergite.

A queen observed May 12, 1952 visiting rose acacia on the Purdue University campus had an apical fringe of white pile on the left side of the second abdominal tergite but this individual escaped.

Bombus (Pratobombus) perplexus Cresson.—In addition to the aberrant colorations reported above, it may be of importance to note the coloration of the pleurae in three workers of *B. perplexus* taken by Mr. Charles Ash in Berrien Co., Michigan. In all three specimens the pleurae are yellow to the leg bases. Individuals so colored cannot be run through most of the keys since typically the pleurae of *B. perplexus* females are dark.

Bombus (Fervidobombus) americanorum (Fabricius).—A queen taken in Clay Co., Indiana on June 14, 1953 by Mr. Bill Butt has an apical, median patch of yellow pile on the fourth abdominal tergite.

Psithyrus (Laboriopsithyrus) laboriosus var. *citrinus* (Smith).—This color variant differs from the typical form (in the male) by having the first three abdominal tergites yellow instead of only the first two. An

unlabelled male, taken from the Purdue Student Collection, has a basal median patch of light yellow pile extending almost to the apical margin of the fourth abdominal tergite.

Distribution Notes

Neither Franklin (1) nor Milliron (2) recorded *Psithyrus (Laboriopsithyrus) variabilis* (Cresson) from Michigan. The author has three females in his collection taken at the Michigan Dunes State Park on June 10, 1950. This species is an inquiline in the nests of *Bombus americanorum.*

Bombus (Subterraneobombus) borealis Kirby has previously been reported from Marshall and Lake Counties, Indiana. A queen of this species was taken by Prof. R. T. Everly of the Purdue Agricultural Experiment Station in LaGrange County, Indiana on August 27, 1952 visiting red clover. On August 13, 1953, Mr. Everly again collected this species on red clover north of Howe in LaGrange County. A total of five specimens were taken including one queen, three workers and one male. This is the first record of a male of *B. borealis* from Indiana. A worker was taken visiting red clover in Noble County by Mr. Everly on August 12, 1953.

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A New Experimental Acaricide and Aphicide

DAN H. LOCKARD, J. I. Holcomb Research Laboratories

Holcomb Compound *326* is a new experimental agricultural chemical developed at the J. I. Holcomb Research Laboratories in Indianapolis early in October of 1952. The material is chemically named Diethyldithiocarbamic phosphorodithioic anhydrosulfide *O*, *O*-diisopropyl ester. Compound *326* is compatible with most of the commonly used insecticides with the exception of strongly alkaline materials such as Bordeaux mixture, lime-sulphur and hydrated lime.

Compound *326* has shown no foliage injury to date when applied at the rate of 2 pounds of 25% wettable powder per 100 gallons, to a variety of greenhouse and ornamental plants, and to fruit, vegetable and field crops. Some phytotoxicity, exhibited by chlorotic spots and marginal leaf burn, has been noticed during the course of evaluating numerous experimental emulsions, however none of the injury can be attributed to *326*, but is due to the use of certain emulsifiers and solvents. Entirely safe emulsifiable concentrates can be prepared with *326* but many formulations must be made to select materials that are not only safe, but also effective and economical.

The mammalian toxicity of *326* indicates that it is slightly less toxic than DDT. The acute oral LD_{50} of *326* in propylene glycol to white Swiss mice is 290 mg/Kg of body weight and 320 mg/Kg to white rats. Rats fed 1/10th of the acute oral dosage daily for six weeks showed no damage to the heart, liver or kidneys when sacrificed. Preliminary tests with isolated strips of turtle heart and rabbit intestine failed to indicate cholinesterase inhibition. Quantitative tests to be conducted in the future may indicate that *326* is a weak inhibitor, however it is not unlikely that it doesn't inhibit as a number of organo-phosphorus materials do not have anti-esterase properties. As cited by Metcalf (1948), tetraethylpyrophosphate is an active esterase inhibitor and triethylphosphate is inactive.

Greenhouse foliage immersion tests at the Holcomb laboratories against the two-spotted mite, *Tetranychus bimaculatus* Harvey, indicate that the material is effective against mites in all stages of development including quiescent phases. Good control of adult mites is obtained at dilutions as low as 0.007% and good control of eggs at 0.015%. In contrast, greenhouse spray tests yield 100% adult mite mortality at 0.03% concentration and 90% egg mortality at the same level. A concentration of 0.06% yields 100% mortality to all stages of mites. From the information just given one can see a considerable difference in the data produced by the two methods but each plays an important part in biological evaluations. Our initial screening test on new compounds employs the foliage immersion method in order to be certain that no material that might show promise is missed because of faulty formulation or impure chemicals. Follow-up tests are conducted with materials that show promise in the immersion test, using spray equipment that produces data more nearly related to data that one might expect to accumulate from field experimentation.

Ovicidal evaluations using 2 pounds of 25% wettable powder per 100 gallons have shown 75 to 100% kill of two-spotted and Atlantic spider mite eggs, *Tetranychus atlanticus* McG., and 2½ pounds has given 85 to 100% kill of European red mite eggs, *Metatetranychus ulmi* (Koch). Tests against eggs of the pear psylla and Mexican bean beetle showed very little promise with greater than 90% of the eggs remaining viable after treatment with the two pound dilution.

In addition to two-spotted, Atlantic and European red mites, *326* has also shown promise against the clover mite, *Bryobia praetiosa* Koch, and citrus red mite, *Paratetranychus citri* (McG.). Compound *326* has given good control of the melon aphid, *Aphis gossypii* Glover; pale chrysanthemum aphid, *Rhopalosiphum rufomaculatum* (Wilson); black chrysanthemum aphid, *Macrosiphum sanborni* Gil.; potato aphid, *Macrosiphum solanifolii* (Ashm.); and the Spiraea aphid, *Aphis spiraecola* Patch. The material has also shown considerable promise against the greenhouse thrips. *326* is apparently not effective against the Mexican bean beetle, eggplant flea beetle, potato flea beetle, imported cabbageworm, cross-striped cabbageworm, striped and spotted cucumber beetles, tomato and tobacco hornworms, southern armyworm, pear psylla, house fly or German roaches.

In greenhouse and field studies *326* has displayed a short residual action which demands that thorough application of spray materials is necessary to achieve good control. *326* affords very little protection against a mite buildup three days after application, however due to *326's* quick killing power and ovicidal properties, one application so reduces the total population that a second application 10 days later kills mites hatched from surviving eggs before oviposition takes place.

In an attempt to explain the short residual action of Compound *326*, three 10 gram samples of technical *326* were exposed in open 3 inch petri dishes under four 36 watt long wave ultra violet bulbs for two, four and six hours. Another 10 gram sample was held in an open 3 inch petri dish but was not exposed to ultra violet light. The materials were not agitated during the exposure period but were examined at intervals to check for changes in color and odor. Before formulation the untreated sample was clear and had the characteristic odor of *326*; the sample exposed to ultra violet for two hours was very slightly clouded in appearance with no detectable change in odor; the sample exposed for four hours was greatly clouded and the intensity of its odor was greatly reduced and after six hours exposure the material was nearly opaque and almost odorless. Even though there were significant changes in appearance and odor, biological tests with the treated samples failed to show any significant difference in toxicity to mites over the untreated sample.

Preliminary tests of *326* for systemic activity have failed to show that the material is systemic, however it is possible that further tests may reveal that at least some of the material is absorbed and either degraded by enzymatic action or diluted in the plant so that it is not toxic to feeding mites. As *326* is apparently stable to light, heat and moisture it is difficult to account for its short residual action. With the development of a satisfactory method of analysis it will be much easier to determine the limiting factors and define the effects of the limiting forces on residual deposits.

The results of field evaluations during the 1953 season indicate that *326* will effectively control two-spotted and European red mites when the 25% wettable powder is applied at the rate of 2 to 2½ pounds per 100 gallons of spray material.

Among the fifteen state and federal experiment stations cooperating in the field evaluation of Compound *326* during the 1953 season, grateful acknowledgment is made to the Purdue University Agricultural Experiment Station, Lafayette, Indiana, and to the U. S. D. A., B. E. P. Q., Fruit Insect Research Division, Vincennes, Indiana. Grateful acknowledgment is also extended to the Department of Pharmacology, Butler University, Indianapolis, Indiana, for their mammalian toxicological studies.

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Additions to the *Coccoidea* or Scale Insects of Indiana (Homoptera)

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Five species of scale insects heretofore unreported from Indiana have been collected or identified by the author during the past four years. These additions to the Indiana fauna raise the total number of species reported from the state to seventy-three. Previously, sixty-eight species of scales have been reported by Douglas (1911), Dietz and Morrison (1916), Amos (1933), and Wallace et al. (1923). The new additions reported by the author are *Phenacoccus dearnessi* King[1], *Aonidomytilis solidaginis* (Hoke)[2], *Lepidosaphes yanagicola* Kuwana[3], *Diaspidiotus liquidambaris* (Kot.)[4], and *Unaspis euonymi* (Comst.)[5].

The description, synonymy, known distribution hosts, and habitat of these five species are listed as follows:

1. *Phenacoccus dearnessi* King. 1901.
   Synonyms: *Phenacoccus cockerelli* King. 1903.
   Phenacoccus betheli Cockerell. 1912.
   Description:
   Adult Female:
   Size: Variable 2.00 to 3.5 mm long, circular in outline.
   Color: Dark red, dorsally covered with transverse bands of a sparse whitish secretion, margins with a short fringe of more or less confluent filaments.

Structural Characteristics: The following is the description of Ferris (1950): "Anal lobe cerarii with 5-10 short, stout, slightly lanceolate setae, these all of about the same size, accompanied by a few trilocular pores and set in a slightly sclerotized area. The remaining cerari of the abdomen contain an even greater number of similar setae, these forming a patch on the side of the body. Anterior to the abdomen these patches become irregular and toward the head can scarcely be distinguished as distinct cerarii. Scattered sparsely over the abdomen are setae similar in form, and in part equal to those of the cerarii. The dorsum bears numerous trilocular pores but no multilocular pores and no tubular ducts.

"Venter with a few multilocular pores which are concentrated in the region of the vulva and do not extend forward to the posterior circulus. Midregion from the anterior abdominal segments forward to the head with scattered, small, quinquelocular pores. A few small, tubular ducts are present, especially on the posterior segments of the abdomen and in the lateral areas.

1. Verified by Dr. Harold Morrison, Div. of Insect Identification, U. S. Dept. of Agr.
2. Determined by Dr. Harold Morrison, Div. of Insect Identification, U. S. Dept. of Agr.
3. Verified by Dr. G. F. Ferris, Stanford University.
4. Determined by Dr. Harold Morrison.
5. Determined by the writer.

"Two circuli present, both these circular or slightly oval and both quite small, the anterior one being smaller than the posterior. Antennae normally nine-segmented, quite short. Legs noticeably short but not especially stout, the claw with a distinct tooth."

The presence of two small circuli and large patches forming the cerarii make this species easily separable from others of the genus.

Hosts: Hawthorn (*Crataegus* sp.), Juneberry (*Amelanchier* sp.), Peach *(Amygdalus havardi).*

Distribution: A series of specimens from hawthorn were sent to the writer by P. T. Ulman from Indianapolis on June 30, 1952. This mealybug has already been reported from Ontario, Canada; Texas; Arizona; California; Colorado; Michigan; and now Indiana.

Habitat: The mealybug occurs primarily on the twigs and stems of the host, usually near the axil of a leaf. See figure 1.

2. *Aonidomytilis solidaginis* (Hoke)
   Synonym: *Lepidosaphes solidaginis* Hoke
   Description:
      Adult female:
         Size: Length 1.2 mm.
         Color: The scale is elongate, pale brown or in part whitish because of a waxy bloom, exuviae is apical. Male scale similar in color and texture but about half the length of the female scale.

Structural Characteristics: Ferris (1937) described *A. solidaginis* as follows: "From the other species of Aonidomytilis, to which genus it is tentatively referred, it differs by the presence of gland spines on the margins of the second to fourth abdominal segments. Median pygidial lobes small and widely separated; second lobes well developed; third lobes represented by a pair of sclerotized points. Dorsal ducts somewhat smaller than the marginal ducts, comparatively few, scattered. Gland spines of the pygidium small, slender, each with a single duct. Perivulvar pores present in five small groups. Pygidium as a whole weakly sclerotized."

Hosts: *Hypericum* sp. (St. John's Wort) and *Solidago* sp. (Goldenrod).

Distribution: This species has previously been reported from Alabama, Mississippi, and now Indiana.

Habitat: This species occurs on the stem and twigs, usually under the curled edge of the exfoliating bark of hypericum. See figure 2.

Notes: This scale was found infesting *Hypericum* in a Lafayette, Indiana nursery by the writer, on November 14, 1951. This is the first report of this scale on *Hypericum* although G. F. Ferris of Stanford University writes "I have had it before from *Hypericum.*" It is very difficult to detect as it is approximately the same color as the thin shreds of bark exfoliating from the small twigs. The scale apparently overwinters as a nearly mature female as no eggs could be found on any of the samples checked.

3. *Lepidosaphes yanagicola* Kuwana. 1925.
Description:
Adult Female:
Size: Length 2.066, width 0.539.
Color: Brown to dark brown, with grayish margins, old specimens gray. Exuviae orange yellow:

Structural Characteristics: Based upon the description of Kuwana (1925):

Scale is elongate, gradually widening posteriorly and convex. Body of female is elongate, not heavily chitinized, slightly narrow toward the anterior end, segmentation distinct; the margins of the abdominal segments not much produced. Pale white in color. Antennae with two short, curved hairs. Anterior parastigmatic glands six to eight. Each margin of the abdominal segments with many small ducts. The last three abdominal segments with a short spur on each margin. Penultimate segment with four gland spines on each margin.

Pygidium—Round, not chitinous. Median lobes large, rather widely separated, rounded somewhat sloping and crenulate; second lobes small, duplex, crenulate, the outer lobules much smaller and sometimes wanting; third lobes wanting. Gland spines rather small and arranged as follows: two between the median lobes, two between median and second lobes, two laterad of second lobes, two beyond these, and two or three additional laterad of this pair. Marginal glands, one laterad of the median lobe, two laterad of the second lobe, two laterad of the fourth pair of gland spines and one laterad of the fifth pair of gland spines. Anal opening close to the base of the pygidium. Circumgenital glands in five groups, the median 6-10, anterior laterals 11-19, posterior laterals 11-18. Dorsal gland orifices rather few and small.

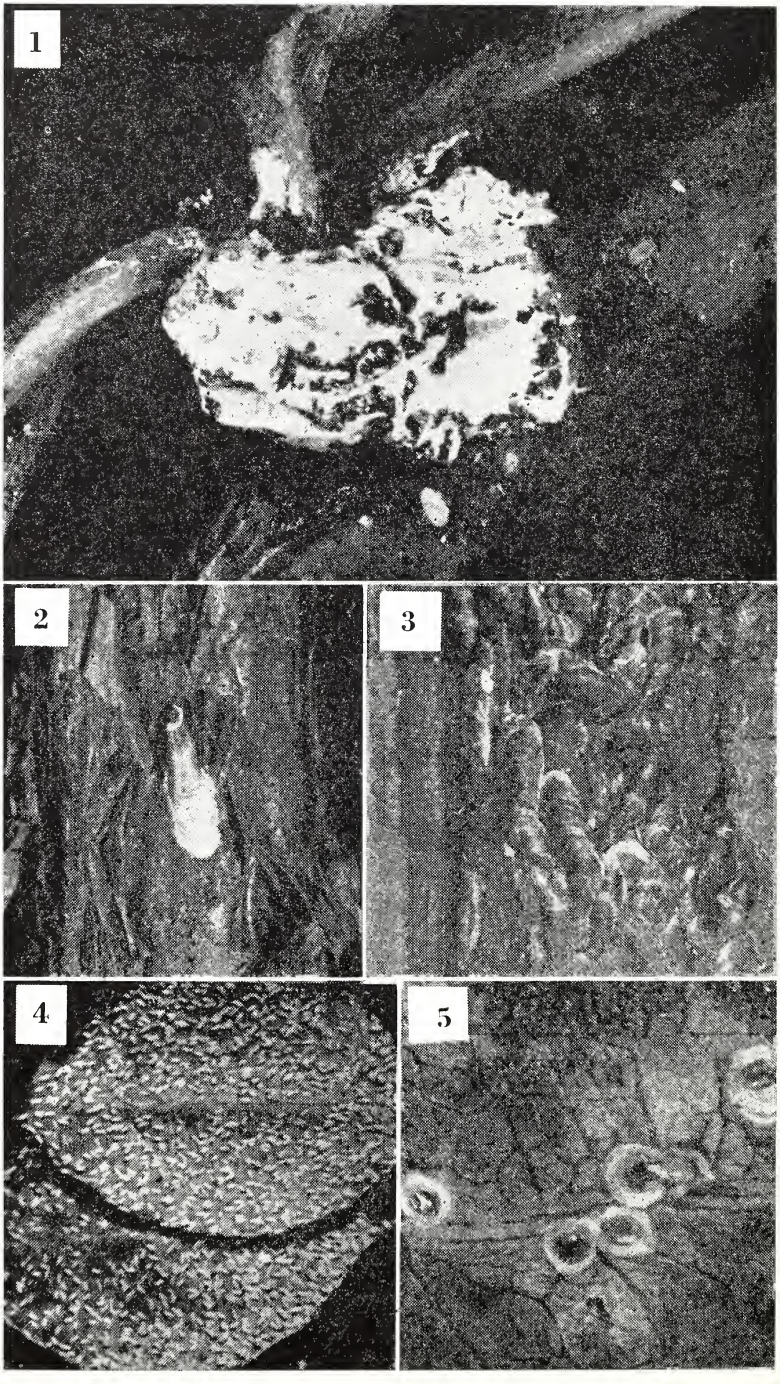
Hosts: *Euonymus alatus* and its varieties; reported on species of Salix (willow) in Japan and Russia.

Distribution: Ohio, Indiana, Japan and Russia.

Habitat: Found on the twigs between the corky ridges, see figure 3. Overwinters as an immature female. Egg disposition begins in June. Apparently there are two generations with second brood eggs deposited in late August and early September.

Notes: In 1950 this scale was found in Ohio by Neiswander, (1953). It was found in several Indiana nurseries by John Favinger and Jim Clark of the State Entomologist's office and in a private planting by the writer.

4. *Unaspis euonymi* (Comstock)
Synonym: *Chionaspis euonymi* Comstock.
Description:
Adult Female:
According to Ferris (1937), "Readily separable from *U. citri* (Comstock), the only other species of the genus known to occur in North America, by the presence of five small groups of perivulvar pores and the lack of sclerotization of the derm of the thorax and first abdominal segment."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Hosts: *Euonymus americanus, E. atropurpureus, E. europeus, E. japonicus* and varieties, *E. latifolius, E. radicans* and varieties. Also on *Althea* spp., *Celastrus* sp., *Syringa* spp. and *Pachysandra terminalis,* according to Boyd (1945). It is serious pest in Indiana on Bigleaf Winter Creeper *E. fortunei (radicans)* var. *vegetus* on which it has been collected repeatedly by the writer during the past four years.

Distribution: According to Ferris (1935): "Undoubtedly introduced into North America from Japan." Also reported from Cuba, France and Italy. It is widespread in the United States, apparently occurring wherever its hosts are found and having been reported from Massachusetts, Connecticut, New York, New Jersey, Pennsylvania, Delaware, Maryland, District of Columbia, Virginia, North Carolina, South Carolina, Georgia, Ohio, Michigan, Missouri, Texas, Mississippi, California, and now Indiana.

Habitat: The conspicuous white males occur primarily on the leaves while the gray, oyster shell-like females occur primarily on the stems and twigs. See figure 4. Heavy infestations cause the leaves to yellow and the plant dies unless control measures are applied.

5. *Diaspidiotus liquidambaris* (Kotinsky)

Synonyms: *Cryptophyllaspis liquidambaris* Kotinsky.
Chemnaspidiotus liquidambaris (Kotinsky).

Description:

Adult Female:

Size: .6 mm in length.

Color and description: Scale flat, white, exuviae central. (Male scale is white, elongate oval, exuviae toward one end.)

Structural Characteristics: The following description is that of Ferris (1938):

"Cephalothoracic region tending to become quite heavily sclerotized at maturity. Perivulvar pores lacking. Median lobes prominent, parallel, separated by nearly half the length of one lobe and with a pair of plates between. Second lobe represented by a long, hyaline, plate-like process and the third lobe with a similar process. Plates well developed, present as far as the seta which marks the fifth segment, slender, simple or variously toothed or fimbriate. Intersegmental marginal scleroses moderately developed. Dorsal ducts relatively few, slender, not present on the fourth and preceding segments except for occasionally one or two ducts on the

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Figure 1. *Phenacoccus dearnessi* King. Woolly mass produced by adults at node of hawthorn twig. Note the two small crawlers.

Figure 2. Adult female *Aonidomytilis solidaginis* (Hoke). On hypericum twig.

Figure 3. Many *Lepidosaphes yanagicola* Kuwana. Clustered on *Euonymus alatus* twig.

Figure 4. Euonymus scale, *Unaspis euonymi* (Comst.). On leaves of big leaf wintercreeper. The white scales on the leaves are males.

Figure 5. *Diaspidiotus liquidambaris* (Kot.). On lower surface of a sweet gum leaf.

fourth segments and small ducts on other segments at the margin. Anal opening slightly less in diameter than the length of the median plates and removed from their base by about twice this diameter." See plate III.

Hosts: Sweet Gum *(Liquidamber styraciflua)*, "red maple," "maple," and magnolia.

Distribution: Recorded from the District of Columbia, Georgia, Mississippi, Florida, Texas, Louisiana and now Indiana.

Habitat: On sweet gum this species causes a pit gall on the leaves. Each gall is capped by a single female scale. See figure 5.

Notes: This species was collected on sweet gum at Indianapolis, Indiana by P. T. Ulman of the State Entomologist's office.

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Observations on the Two Forms of the Periodical Cicada *Magicicada septendecim* (L)

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Introduction

Magicicada septendecim (L.) occurs, at least in Indiana, in two markedly different forms, one large and the other small. In the small form, both sexes measure abou 25 millimeters to the tip of the abdomen, and the males 32 and the female 36 millimeters to the tip of the folded wings. In the large form, both sexes measure about 29 millimeters to the tip of the abdomen, and the males 39 and the females 42 millimeters to the tip of the folded wings. According to Deay (1953) the small form was described as a new species, *M. cassinii* by Fisher in 1851, but was considered only a variety of *M. septendecim* by Riley (1885).

During the emergence of brood X in 1953, the writer made some studies of the habits of the two "races" near Bloomington, Monroe County, Indiana where both forms occurred in profusion.

Emergence

The first individual to be observed emerging, May 7, was a large form, followed by other large forms during the next three days. Since only fifteen individuals were observed emerging between May 7 and May 11, small forms could easily have been emerging in similar numbers unnoticed. Small forms were observed to emerge on May 11, after which time both forms were observed to emerge in numbers. The holes left in the ground following emergence were often rather permanent and were inhabited by numerous insects, including wasps.

The cast skins of the two races were distinct in size, those of the small race measuring only about 23 millimeters to the tip of the abdomen, while those of the large race measured 27 millimeters. (The skins vary considerably in size due probably to shrinkage and torsion, but the two forms were, overall, quite distinct.)

Sex Ratio

Counts of cast skins of the small forms showed females to exceed males by 3800 to 1600, or 2.4:1. Counts of those of the large forms similarly showed females to exceed males 4600 to 3000, or 1.5:1.

Behavior of the Adults

The first individual to be heard singing (May 15) was a large form, to be followed by other large forms in increasing numbers. The first small form was not heard singing until May 20. After May 25, both forms were heard in large numbers.

The songs of the two forms were clearly distinct, that of the large forms being a low trill similar to the trill of the American toad, *Bufo americanus*, while that of the small forms was a high pitched tone resembling the song of the harvest fly, *Tibicen linnei*, and closely resembling the sound of a large electric motor. Although the large forms sang in a steady trill, the songs of the small forms modulated in frequency, since the males sing in unison at temperatures approaching or exceeding 30° C. The males singing in unison were gathered into assemblages in single trees or in groups of trees throughout the countryside. Each assemblage had its individual rise and fall of modulation, but the overall frequency of modulations was remarkably constant, eleven per second, at temperatures exceeding 30° C. One assemblage, in a shaded grove of slippery elms, was found to maintain a frequency of only ten per second from day to day while other assemblages, in sunny situations, were modulating at eleven per second. The modulation rose in frequency as the temperature rose in the day, the lowest frequency being seven per second heard when the temperature was rising from 27 to 28° C. within a period of five minutes.

The large forms began singing earlier in the day and at lower temperatures than the small forms. The small forms were usually almost silent on days when the temperature was not rapidly rising above 28° C., but the large forms were often very vociferous at this time.

By July 7, the small form was heard only as individuals, although the air temperature rose to 29° C. on this date. The large forms were, however, still uniformly noisy on July 7. On July 8, the maximum air temperature was again 29° C., and the first *Tibicen linnei* was heard: *M. septendecim* behaved much as on July 7. On July 9-12, the maximum temperature was only 25° C., and no cicadas were heard. *M. septendecim* was last heard on July 8.

Studies on Host Preference of the Size Forms

It was noted that the two forms, although overlapping on many trees, seemed in general to be isolated. In noting the trees inhabited by the two forms, it was found that the large forms were present almost to the exclusion of the small forms in shaded groves of the beech, *Fagus grandifolia*. On the other hand, the small forms preponderated on most of the other trees, and on many trees they were present to the exclusion of the large forms. The small forms seemed to show a marked preference for the green ash, *Fraxinus lanceolata*. Other trees on which the small forms were found in the great majority were: white ash, *Fraxinus americana;* slippery elm, *Ulmus fulva;* american elm, *Ulmus americana; Crataegus* sp.; apple, *Pyrus Malus;* pear, *Pyrus communis;* wild cherry, *Prunus serotina;* sycamore, *Platanus occidentalis;* honey locust, *Gleditsia tricanthos;* and walnut, *Juglans nigra*. The two forms were present in about equal numbers on beeches in the open, and one or the other form would preponderate where beeches were mixed with other trees. Collections of cast skins showed skins of the large form to preponderate under beeches, and those of the small form to preponderate under the other trees. Collections of skins in shaded beech groves showed almost all large

forms to be present, and similar collections in elm groves showed almost all small forms to be present.

On trees where the two forms were found together, examination of numerous pairs failed to disclose evidence of intermating between the two forms.

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Preliminary Report on the Relative Attractiveness of Different Heights of Light Traps to Moths

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J. G. TAYLOR, U. S. Department of Agriculture

The use of light traps to determine the presence and abundance of insects, especially moths, has increased in the last few years. These traps are usually placed in barnyards where electricity is readily available rather than in fields of growing crops. Considerable work has been done on the most effective heights to place traps in a cornfield to protect the corn from the European corn borer, but no work has been reported on the best height to place traps to capture insects when the traps are located at some distance from the crops attacked.

The writers started preliminary work on this problem in the summer of 1953. Four one-directional light traps, each illuminated with a 15-watt BL lamp, were placed on the same pole (Figure 1) at heights of 4, 8, 12 and 16 feet above the ground. They were placed in the barnyard at the Purdue Electric Farm and were beamed over a well pastured blue grass pasture. There were no vegetables or field crops for a distance of 40 rods in front of the traps. There was a corn field about 10 rods to the left of the traps but it was not in the direct beam of the lamps. Thus there was no vegetation except the short blue grass to attract the insects to the immediate vicinity of the lights and no cover to harbor the insects during the day. Consequently most of the insects captured must have been ones which had been cruising by.

The traps used in this experiment (Figure 2) were of original design and were constructed in the Purdue Agricultural Engineering shop. They were made of 26 gauge galvanized metal. The overall dimensions were 18" wide, 18" high (excluding the collecting jar), and 11" deep. The top of the trap extended slightly below the top of the opening to aid in excluding rain. The effective opening measured 3½" by 18". The 15-watt lamp in each trap was mounted so that it was visible approximately 30° above and 30° below the horizontal in the vertical plane and over a total included angle of approximately 165° in the horizontal plane. Below the lamp a flattened funnel with a top opening of 5" by 18" tapered at a 45° angle to a 2" square opening to which was attached a wide-mouthed Mason jar which was charged with calcium cyanide.

These traps were operated continuously from the night of June 16 through that of September 7. The insects were removed from the jars each day.

Species of Moths Included in Study

Of the many insects caught during the season the following 28 species of moths were selected for this study because of the economic importance of their larvae. The sex and the number of individuals of each species caught each night were recorded. In the case of the corn earworm it was determined if the females were gravid.

Family Arctiidae	
Diacrisia virginica (F.)	yellow woollybear
Estigmene acrea (Drury)	salt-marsh caterpillar
Isia isabella (A. & S.)	banded woollybear
Family Phalaenidae (Noctuidae)	
Agrotis ypsilon Rott.	black cutworm
Amathes c-nigrum (L.)	spotted cutworm
Ceramica picta (Harr.)	zebra caterpillar
Crymodes devastator (Brace)	glassy cutworm
Feltia ducens Walker	"a cutworm" [1]
F. subgothica (Haw.)	dingy cutworm
F. subterranea (F.)	granulate cutworm
Graphiphora bicarnea (Guenee)	"a cutworm" [1]
Heliothis armigera (Hbn.)	bollworm, corn earworm tomato fruitworm
Lacinipolia renigera (Steph.)	bristly cutworm
Laphygma frugiperda (A. & S.)	fall armyworm
Peridroma margaritosa (Haw.)	variegated cutworm
Plathypena scabra (F.)	green cloverworm
Polia subjuncta G. & R.	"speckled cutworm" [1]
Prodenia ornithogalli Guenee	yellow-striped armyworm
Protoleucania albilinea (Hbn.)	wheat head armyworm
Pseudaletia phragmatidicola (Guenee)	"yellow armyworm" [1]
P. unipuncta (Haw.)	armyworm
P. ursula (F.)	"an armyworm" [1]
Scotogramma trifolii (Rott.)	clover cutworm
Sideridis rosea (Harvey)	"no common name" [1]
Family Pyralididae	
Pyrausta nubilalis (Hbn.)	European corn borer
Family Sphingidae	
Ceratomia catalpae (Bdvl.)	catalpa sphinx
Protoparce quinquemaculata (Haw.)	tomato hornworm
P. sexta (Johan.)	tobacco hornworm

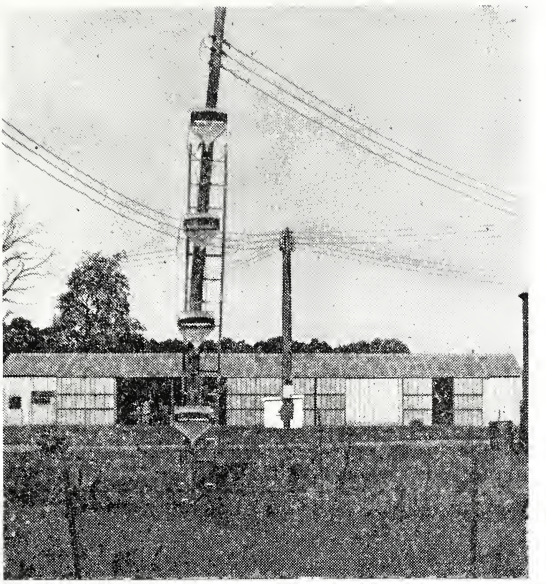
Results: It was observed that insects which were attracted to the 16-foot trap were in many instances captured at one of the lower traps. In general it may be said that if the moths did not immediately enter a trap they would circle and enter a trap at a lower level. Rarely would they enter a higher trap. This means that the number of moths captured at the 16-foot trap is probably smaller than it would have been had the other lights not been present and that the number caught at the 4-foot trap is probably considerably larger than it would have been had the other lights been absent.

As shown in Table 1 approximately equal numbers of individuals were captured at the 4-foot and the 16-foot traps and that more were

1. No common name has been approved by the Entomological Society of America.

TABLE 1. Moths caught at light traps placed 4, 8, 12 and 16 feet above the ground. Nights of June 16 through September 7, 1953. Lafayette, Indiana.

Species	No. Insects			Per Cent Total Catch and Per Cent Total Females Caught at							
				4-ft. Trap		8-ft. Trap		12-ft. Trap		16 ft. Trap	
	Fem.	Male	Tot.	Tot.	Fem.	Tot.	Fem.	Tot.	Fem.	Tot.	Fem.
Family Arctiidae											
Diacrisia virginica	26	215	241	46.1	57.7	28.6	26.9	14.1	7.7	11.2	7.7
Estigmene acrea	8	74	82	64.6	87.5	13.4	12.5	14.6	0.0	7.3	0.0
Isia isabella	4	12	16	31.2	0.0	37.5	50.0	12.5	25.0	18.8	25.0
Family Phalaenidae											
Agrotis ypsilon	58	39	97	21.6	20.7	19.6	19.0	19.6	20.7	39.1	39.7
Amathes c-nigrum	6	20	26	23.1	16.7	19.2	33.3	7.7	0.0	50.0	50.0
Ceramica picta	0	10	10	80.0	...	20.0	...	0.0	...	0.0	...
Crymodes devastator	4	3	7	14.3	0.0	57.1	75.0	14.3	25.0	14.3	0.0
Feltia ducens	77	271	348	53.7	41.5	19.8	19.5	13.2	16.9	13.2	22.1
F. subgothica	59	84	143	59.4	45.8	18.9	25.4	14.0	22.0	7.7	6.8
F. subterranea	26	3	29	3.4	3.8	20.7	23.1	31.0	26.9	44.8	46.2
Graphiphora bicarnea	1	2	3	0.0	0.0	0.0	0.0	33.3	100.0	66.7	0.0
Heliothis armigera	239	117	356	27.8	29.3	17.4	19.7	31.7	28.0	23.0	23.0
Lacinipolia renigera	183	246	429	26.6	25.1	20.7	23.5	20.0	21.9	32.6	29.5
Laphygma frugiperda	54	186	240	18.3	20.4	25.4	35.2	20.8	14.8	35.4	29.6
Peridroma margaritosa	187	146	333	14.7	14.4	21.0	19.2	21.3	19.2	42.9	47.1
Plathypena scabra	13	109	122	38.5	23.1	18.9	30.8	21.3	23.1	21.3	23.1
Polia subjuncta	2	4	6	16.7	0.0	16.7	0.0	50.0	100.0	16.7	0.0
Prodenia ornithogalli	69	179	248	24.6	27.5	21.8	26.1	23.0	24.6	30.6	21.7
Protoleucania albilinea	10	47	57	38.6	40.0	24.6	10.0	15.8	10.0	21.0	40.0
Pseudaletia phragmatidicola	9	20	29	34.5	33.3	3.5	0.0	34.5	33.3	27.6	33.3
P. unipuncta	428	324	752	14.8	16.4	17.2	17.1	22.6	22.4	45.5	44.2
P. ursula	4	11	15	33.3	25.0	20.0	25.0	6.7	0.0	40.0	50.0
Scotogramma trifolii	19	14	33	30.3	31.6	30.3	42.1	24.2	15.8	15.2	10.5
Sideridis rosea	2	0	2	0.0	0.0	0.0	0.0	100.0	100.0	0.0	0.0
Family Pyralididae											
Pyrausta nubilalis	44	27	71	29.6	29.5	16.9	18.2	32.4	36.4	21.1	15.9
Family Sphingidae											
Ceratomia catalpae	16	31	47	36.2	25.0	25.5	31.2	19.1	31.2	19.1	12.5
Protoparce quinquemaculata	37	120	157	33.1	45.9	20.4	13.5	21.7	16.2	24.8	24.3
P. sexta	55	189	244	33.2	41.8	23.8	30.9	20.1	9.1	22.9	18.2
Totals	1639	2504	4143	29.5	25.1	20.5	21.2	20.9	22.0	29.1	31.8



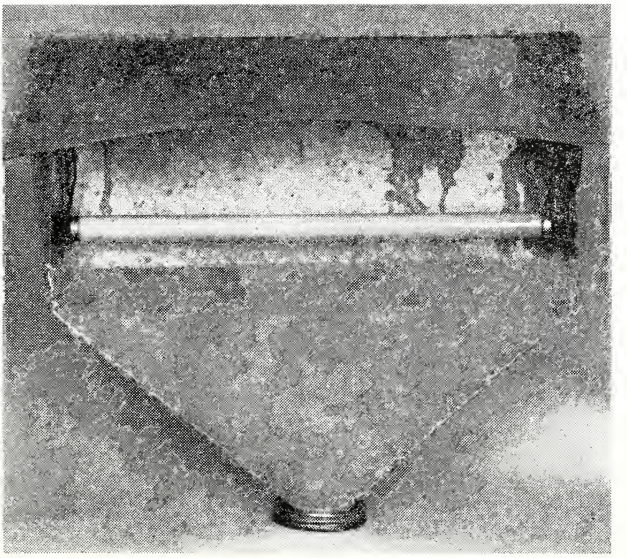


Figure 1. The light traps were placed at heights of 4, 8, 12 and 16 feet above the ground.

Figure 2. Close-up of light traps used in the experiments.

caught at each of these than at either the 8-foot or the 12-foot trap. The most females were caught at the 16-foot trap and the most males at the 4-foot one. Of the 28 species included in this study representatives of both sexes of all species except *C. picta*, where no females, and *S. rosae*, where no males, were captured. Representatives of all but two of the species *(G. bicarnea* and *S. rosae)* were caught by the 4-foot and 8-foot traps, of all but *C. picta* at the 12-foot, and of all but *C. picta* and *S. rosae* at the 16-foot.

The three species of Arctiidae studied showed a decided preference for the 4 and 8-foot traps. The paucity of females captured may be explained by the fact that they are weak fliers and stay close to the ground.

Of the cutworms *A. ypsilon, A. c-nigrum, F. subterranea, L. renigera* and *P. margaritosa* showed a decided preference for the 16-foot trap. Over 50 per cent of *F. ducens* and *F. subgothica* were caught by the 4-foot trap. *P. ornithogalli* came in about equal numbers to all the traps, but tended to favor the 16-foot one.

The armyworm, *P. unipuncta*, showed a decided preference for the 16-foot trap. The fall armyworm, *L. frugiperda*, preferred the 16-foot with a secondary preference for the 8-foot.

The tobacco and tomato hornworm moths have been observed to cruise at heights of 15 to 35 feet, but about equal numbers of males were caught at all four traps, and about 50 per cent of the females at the 4-foot one.

The highest number of moths of the corn borer *(P. nubilalis)* and the corn earworm *(H. armigera)* were caught at the 12-foot trap and the next highest at the 4-foot one. Ninety-one per cent of the female corn earworm moths caught at the 4-foot trap, ninety-six per cent of those at the 8 and 12-foot traps, and 100 per cent of those at the 16-foot trap were gravid.

In examining the data to determine the length of time the various species were active, it was found that of the 25 species taken at all four traps, eight were present the first night the traps were operated and came to all four traps. Of the other 17 species nine made their first appearance at either the 4 or 8-foot trap (usually the 4-foot one) and eight at either the 12 or 16-foot trap (usually the 16-foot). This preference for high or low traps was followed in general throughout the period of flight.

Judging from the results obtained in this preliminary study it appears that when light traps are placed near the barnyard in order to determine the kinds and numbers of insects present and the period of their activity, at least two light traps should be placed on the same pole—one near the ground and the other at a height of 12 or 16 feet.

Tingoidea (Hemiptera) of Tippecanoe County, Indiana[1]

CHARLES R. ASH, Riverside, California

Only two Tingoidea, or lace bugs, have previously been reported from Tippecanoe County. Davis (2) reported *Corythucha marmorata* (Uhler) abundant on chrysanthemum in Lafayette, and (3) *C. ciliata* (Say) abundant in Lafayette. Blatchley (1) gives some general distribution records of the Tingoidea in Indiana but does not mention Tippecanoe County.

Examination of a personal collection and three Purdue University collections revealed a total of thirteen species, encompassing four genera and two families, occurring in Tippecanoe County. One new record was obtained for Indiana.

List of the Species of Tingoidea Occurring in Tippecanoe County, Indiana, with Their Principal Hosts.

Piesmidae

Piesma cinerea (Say), 1831. On *Amaranthus* sp. (pigweed).

Tingidae

Gargaphia solani Heidemann, 1914. On *Solanum melongena* (eggplant).

Gargaphia tiliae (Walsh), 1864. On *Tilia americana* (basswood).

Corythucha aesculi Osborn & Drake, 1916. On *Aesculus glabra* (Ohio buckeye).

Corythucha arcuata (Say), 1832. On *Quercus alba* (white oak), and *Quercus Muhlenbergii* (chinquapin oak).

Corythucha associata Osborn and Drake, 1916. On *Prunus serotina* (black cherry).

Corythucha celtidis Osborn and Drake, 1916. On *Celtis occidentalis* (hackberry).

Corythucha ciliata (Say), 1832. On *Platanus occidentalis* (sycamore).

Corythucha cydoniae (Fitch), 1861. On *Crataegus* spp. (hawthorn).

Corythucha juglandis (Fitch), 1857.

Corythucha marmorata (Uhler), 1878. On *Solidago* sp. (goldenrod), *Aster* sp. (aster), and *Helianthus tuberosus* (Jerusalem artichoke).

Corythucha ulmi Osborn and Drake, 1916. On *Ulmus americana* (American elm), *Ulmus fulva* (slippery elm), and *Ulmus glabra camperdowni* (camperdown elm).

Physatocheila brevirostris Osborn and Drake, 1916. (This species has heretofore been unrecorded from Indiana.)

Literature Cited

1. BLATCHLEY, W. S. 1926. Heteroptera or True Bugs of Eastern North America. Nat. Pub. Co., Indianapolis.
2. DAVIS, J. J. 1932. Insects of Indiana for 1932. Proc. Ind. Acad. Sci. 42 :222.
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1. This is a part of an undergraduate thesis submitted to Purdue University in partial fulfillment for the degree of Bachelor of Science in Agriculture.

SYMPOSIUM

The Effects of Continued Widespread Use of Organic Insecticides

INTRODUCTION

M. Curtis Wilson, Purdue University

The dominant problem in applied entomology today is the determination of the effects of the use of organic insecticides on the world and civilization. It is a problem which has arisen in very recent times and a problem of great concern. It is a relatively new problem because the organic phosphate and hydrocarbon insecticides did not come into general use until the years following World War II. We are all aware of the stimulus the discovering of the killing powers of DDT had to chemical control of insects.

Following only a few years of insecticidal use, many problems have become apparent and scientists are confronted with many questions which with available data can be answered only in part. In this symposium the general topic has been divided into four parts as follows: The effects of continued widespread use of organic insecticides on, 1. the insect balance of nature; 2. wild life other than insects; 3. plants and soil; and 4. human health.

Effects on the Insect Balance of Nature.[1] Frank N. Young, Indiana University.—The use of organic insecticides against insect pests has been extended so rapidly in recent years that the long range effects of continued widespread use are still unpredictable. The areas involved and the amounts of material used are still too small to effect massive changes in the natural insect fauna of the earth. Even the extensive forest spraying programs, such as those in New England and in southern Canada, do not give us positive evidence that the balance of nature, if such exists, has been seriously upset. Neither the ebullient prognostications that the organic insecticides were the panacea for all our control problems, nor the dire forebodings that they would completely destroy our beautiful and delicate wildlife have been realized. We are gradually achieving a better perspective in regard to the toxic organic compounds as useful tools of the economic entomologist—some better, some poorer than others at his command.

It is quite evident, however, that if we apply organic insecticides or any other highly toxic material in heavy concentrations to a limited area certain disturbances of the insect fauna follow. Often, the most immediate result is that the pest against which we applied the poison increases

1. Contribution No. 543 from the Zoological Laboratories of Indiana University.

out of all proportion after the insecticide loses its toxicity. Another effect which becomes evident over a period of time is the increased resistance of certain pests to particular insecticides.

The first of these effects is clearly seen in the use of DDT oil or emulsion sprays on small ponds, or catchments. Almost invariably, after a certain lapse of time, pest or disease-carrying mosquitoes increase greatly in such situations so that repeated spraying is necessary. It seems evident that the great increase in the pest insect is due to the reduction of natural competitors, predators, and parasites. The changes in abundance follow Volterra's mathematical generalization that if a population is being destroyed uniformly by an outside agent, eaten animals tend to increase and eaters tend to decrease. If left alone the various organisms return to a relative balance with seasonal and other rhythms dependent upon increases or decreases in the initial conditions. (See appendix in Chapman, *Animal Ecology*, 1931).

The same general principles apply to many insect populations. The use of organic insecticides on citrus and other tree crops almost always results in the subsequent increase of red mites or other pests. Experiments have shown that these increases are largely due to the reduction of predators or parasites, but they may also be partly the result of dispersal of the organisms throughout the area involved. A recent example is the increase of the Oriental fruit moth on peaches in Virginia, following the spraying of orchards with BHC for control of the plum curculio. Here the moth was formerly kept in check by larval parasites which were apparently reduced in numbers by the spray program. (See Bobb, *J. Econ. Ent.*, 44:418-420, 1951.)

Under many conditions, the unbalancing of the population system in a situation is of no importance to the entomologist. For example, on a small army post in a relatively well-drained region it is possible to spray periodically every mosquito breeding situation which cannot be drained or filled. On the other hand, taking a long term view of the results, such an intensive control program may be very dangerous to the human population involved. On the Gold Coast of Africa our elaborately sanitated bases protected for a time a considerable number of natives, who having lost their immunity to malaria (or their chronic infections) were severely affected when the bases were abandoned at the end of the war.

The use of organic insecticides has also been shown to have disadvantageous effects in destroying predators and parasites in field crops under certain conditions. Willie (*J. Econ. Ent.*, 44:13-18, 1951) reports a very interesting result of spraying cotton with various compounds (BHC, toxaphene, DDT, and others) in Peru. He found that under normal conditions the principal cotton pest of the area, *Heliothis virescens*, was rather effectively controlled by various hemipterans which are predators on the eggs of the moth. The bugs destroyed up to 90% of the eggs, while DDT, the most effective poison used, killed only 75% of the eggs, and larvae. Spraying with any of the toxic compounds, however, resulted in increased damage after their toxicity had worn off. He suggests timing of irrigation together with natural controls to minimize damage under the conditions present.

The production of resistant strains by insecticide action may also upset the natural balance, and forms resistant to insecticides may show different behavior patterns and characteristics which lessen the effectiveness of natural predators or parasites. The increased resistance of houseflies to DDT is a well-known example of this phenomenon. We might raise a question in regard to using insecticides with different modes of toxic action on resistant strains: Will continued selection produce super-super resistant insects?

Various suggestions have been made in recent years for lessening the disadvantageous effects of applications of toxic materials and for bringing the chemical control program into better balance with biological control (See DeBach, *J. Econ. Ent.*, 44:443-447, 1951). Selective insecticides which kill the pests, but not their predators or parasites seem to offer a promising lead. Recent experiments have involved such clever techniques as coating DDT pills with hemicellulose making them lethal only to phytophagous insects which have the enzyme hemicellulase to dissolve the covering. Systemic insecticides which are transported by the plant to sap-sucking insects are another possibility. In the latter, however, the problem of toxic, unpleasant, and other residues is important (See Ripper, *et al., J. Econ. Ent.*, 44:448-459, 1951.)

The problems of unbalanced populations resulting from the continued large scale use of organic insecticides are essentially ecological. They involve the problems of the habitat complex and the concept of biotic communities. Many interesting lines of research are indicated, but they all seem to lead toward more intensive cooperation among many different fields. Perhaps we have placed too much emphasis on the complete control of insect pests. The possibility of an intermediate stand in which we give up part of our superfluities in exchange for long-term advantages should be investigated further.

Effects on Wildlife Other Than Insects. WILLIAM D. FITZWATER, JR., U. S. Fish and Wildlife Service, Purdue University.—The history of economic entomology has been a progression more rapid in recent years, from the more innocuous insecticides, such as pyrethrins, to the more dangerous, such as the organic phosphates. The need for these more toxic substances in controlling obnoxious insects in agricultural and forest areas has presented a new hazard to our wildlife resources. The influence of these organic insecticides may be felt in at least four ways:

1. Primary Poisoning

Primary poisoning is the direct destruction of wildlife through skin absorption or the ingestion of poisoned vegetation. Field applications for insect control are generally at concentrations that present little or no danger to vertebrate animals from direct poisoning. Mitchell (J. Wildlife Mgt., 10:192-194, 1946) found that even at the rate of 5 pounds per acre, DDT sprayed directly over the immediate nest area of various species of birds had no detrimental effect upon the hatching of eggs or the development of young. Other studies (See Stickel, J. Wildlife Mgt., 10:216-218, 1946) have shown that the actual deposition of insecticide on the vertebrate animals' habitat is a very minute fraction of the actual poundage applied.

Therefore, in the treatment of agricultural and forest crops it seems certain that when minimal amounts are applied the danger of killing vertebrates directly is of minor significance.

This discussion would not be complete without a word concerning the intentional use of organic insecticides in the control of injurious wildlife. Rotenone has been used as a fish poison long before it was utilized for the control of insects. Nicotine has been recommended for controlling unusual snake populations under drought conditions (See Stickel, U. S. F. W. S. Leaf. 345, 1953). Several chlorinated hydrocarbons have shown rodenticidal possibilities as tracking dusts for the control of house mice (See Smith, Unpubl. Ms., Ohio State Univ., 1951). The most recent development has been the use of ground sprays of chlorinated hydrocarbons or organic phosphates for the control of field mice in orchards. While toxaphene, aldrin and dieldrin have shown the most promise in this respect, the concentrations necessary to control mice constitute a real hazard to beneficial wildlife and domestic animals using the same areas.

2. Secondary Poisoning

Secondary poisoning is mortality caused by the consumption of poisoned insects by vertebrate predators. Here the evidence is even more fragmentary under actual field conditions. George and Mitchell (J. Econ. Ent., 40:782-789, 1947) found that in a forested area treated for spruce budworm infestation with DDT, nestlings that received both poisoned and unpoisoned material were not affected. Under controlled conditions where the nestlings were fed exclusively on sprayed material, mortality was high from loss of vitality due to a starvation diet and a high susceptibility to DDT toxicity. Therefore, it is logical to suppose that when young on the nest are fed high portions of DDT-poisoned insects and later receive an insufficient food supply due to the scarcity of insect life, the bird population would suffer markedly.

3. Limitation of Food Supply

The limitation of available food for insectivorous wildlife is a necessary corollary to area treatment with insecticides. This factor is taken advantage of in one of the recommended controls for moles. The formation of barriers with chlordane, DDT, etc., has been found effective in limiting the movements of moles by the creation of foodless areas. Extensive spraying undoubtedly has some influence on bird populations as insect samples have shown that six to seventeen times as many insects are found on unsprayed plots as compared with treated plots (See Mitchell, et al., J. Wildlife Mgt., 17:45-54, 1953). Inasmuch as it takes six to eight weeks before the insect populations return to normal, this must exert a very significant influence on the bird population, particularly when the treatment coincides with the nesting periods.

4. Reduction of Ectoparasites

Lowering natural mortality of wild species by the reduction of their insect parasites is probably of minor importance under field conditions. The use of DDT dust, however, is a recommended supplement to rat control measures in typhus areas to reduce movement of the disease vectors

from dead rats to human hosts (See Hill, et al., Am. J. Pub. Health, 41: 396-401, 1951).

The value of wildlife is based mostly on intangibles rather than dollars and cents. Therefore, it is inevitable that economic pressure will cause more extensive use of insecticides in direct conflict with the welfare of our wildlife. This conflict can be lessened somewhat if attention is given the following recommendations:

1. Limit the application of insecticides on an area basis to minimal areas. Use insecticides as a rapier not as a broadaxe. Weigh carefully the value to be received from the control measures against the dangers to wildlife. Where possible in the treatment of extensive areas leave sanctuary strips to aid the wildlife in weathering the lean period until the insect population builds up again.

2. Use the minimal amount required to kill the insects. With DDT, for example, it has been found that in tracts sprayed at the rate of five pounds per acre the bird population dropped from 3.2 per acre to 0.5 per acre within two weeks (See Hotchkiss and Pough, J. Wildlife Mgt., 10:202-207, 1946). On the other hand, where only one pound per acre was used there was no significant change in the avian population. Cottam and Higgins (U. S. F. W. S. Circ. 11, 1946) have recommended that less than 1/5 pound per acre of DDT be used to prevent danger to fish and reptiles while 2 pounds per acre should be the maximum for the safety of birds and mammals.

3. Spray before or after the chief bird nesting periods. Take advantage of the residual effect and treat just before the emergence of leaves and the arrival of birds from the south. When sprays are indicated later in the season they should be delayed until mid-August in Indiana. At that time the main nesting period has passed.

4. Avoid direct application of sprays to bodies of water. Inasmuch as fish have been shown to be very susceptible to DDT, care should be taken in aerial spraying to avoid water areas.

5. Choose oils or wettable powders in preference to emulsions. Emulsions, being more readily absorbed, are more deadly to vertebrate species. Surber (J. Wildlife Mgt., 10:183-191, 1946) showed that DDT wettable powders killed only a few fish. In ponds treated with DDT in oil, fifty to sixty per cent of bluegills were killed, but only a few bass were lost. However, in ponds treated with emulsions all the fish were killed.

Effects on Plants and Soil. D. W. HAMILTON, U. S. D. A., Agr. Res. Serv., Bureau of Entomology and Plant Quarantine.—Injury to crops from accumulation of insecticides in the soil is not new. Headden (Colo. Agr. Expt. Sta. Bul. 131, 1908) reported symptoms of injury from accumulations of lead arsenate in soils of Colorado orchards. In the Northwest, many growers have used 300 pounds of lead arsenate or more per acre each season for many years.

Boswell (U. S. D. A. Yearbook, pp. 284-296, 1952) reported that as much as 1,400 pounds per acre of arsenic trioxide had been found in the surface 8 inches. However, in general, apple trees were not seriously affected as their roots were below the surface 6 to 8 inches of soil. Serious injury and sometimes crop failures resulted when shallow-rooted cover

crops were planted in such orchards, or when the trees were removed and replaced with other crops. Injury to alfalfa, beans, and peas was especially prevalent. Crops less sensitive but showing some injury were tomatoes, asparagus, and grapes. Fortunately, the high arsenic toxicity of these soils is gradually decreasing.

DDT, the first of the new organic insecticides, was not developed as an insecticide in this country until 1943 and was not extensively used before 1945. Dieldrin, another of the new organic insecticides now being widely used, was not formulated until 1949. Since these insecticides have been used over such a short period, it is difficult to determine accurately the possible amount of plant injury from accumulated residues in the soils.

Immediate determination of the sensitivity of various plants to insecticides can best be made by subjecting them to abnormally high concentrations of insecticides in the soil. If no serious injury is apparent, it can be assumed that accumulations over a period of years are not likely to be detrimental. If small accumulations in the soil produce undesirable results, it is important to determine what plants are sensitive to the chemical and the amounts they can tolerate.

Organic insecticides vary greatly in their stability. Among the least stable are the phosphorus insecticides; DDT is one of the most stable. Persistence of these chemicals often is beneficial for the control of insects, especially those in the soil, but it may also permit a rapid buildup of toxic residues within the soil. High-volume spraying such as that used for the control of orchard insects causes the insecticides to build up the most rapidly in the soil. Chisholm *et al.* (*Jour. Econ. Ent.* 43:941-42, 1950) showed that in southern Indiana, where an average of seven applications of DDT were made on apples each year, accumulation of DDT in the soil and surface debris after 5 years of spraying was as much as 194 pounds per acre. Like the arsenicals, most of the DDT was near the surface of the soil, as shown in samples collected under apple trees; 90.7 percent was in the surface debris, 6.7 percent in the top 3 inches of soil, and 2.6 percent in a layer 3 to 6 inches deep. Deposits are not found below the top 6 or 8 inches of soil unless carried there and redistributed during cultivation or plowing.

Hoyt (U. S. D. A. Ann. Rpt. p. 75, 1952) reported that Japanese beetle investigations showed that average losses of DDT in the soil after 2 years was 8 percent, after 6 years 64 percent, and after 7 years 71 percent. A summary of the effects of residues in soils on plants by Boswell (1952) shows that germination and stands of corn were reduced where DDT was used at 100 to 400 pounds per acre, but they were exceptional cases. In other instances dosages of 1,000 pounds per acre had no effect. Residues from dosages of 50 to 100 pounds of DDT per acre reduced the growth of Abruzzi rye. It formed a poor cover crop in a peach orchard where DDT had been used for 4 years. Potatoes were highly tolerant to DDT in the soil. Cabbage, broccoli, collards, and turnips were not adversely affected by dosages up to 400 pounds. Legume plants reacted differently to DDT in soils. Snapbeans and lima beans were sensitive, some kinds very much so. Stringless Black Valentine snapbeans were heavily injured by as little as 25 to 50 pounds of DDT to the acre, and

yields were reduced as much as 50 percent with 200 pounds of DDT to the acre. Spinach, beets, and tomatoes are all sensitive to DDT in the soil. Cucurbits, such as pumpkins, squash, and cucumbers, are highly sensitive to DDT, although there are numerous exceptions. Muskmelons are less sensitive than other cucurbits.

Among the fruits, peach is known to be sensitive when its feeding roots are exposed to DDT. Several investigators have reported that strawberries are highly sensitive, light dust having prevented the formation of young plants in some instances. Allen *et al.* (U. S. D. A. Tech. Bul. 1047, 1951) have shown that cotton is unaffected by DDT in the soil. In their studies tobacco showed chlorosis and the yield and burning quality were reduced slightly when it was grown in soil containing 100 pounds of DDT per acre.

Fleming (Bur. Ent. and Pl. Quar. E-737, 1948) reported that numerous species of plants subjected to normal dosages of DDT used for grubproofing soil—25 pounds per acre—were not affected by DDT. Out of 963 plant species observed 958 were unaffected.

The reaction of plants to DDT in the soil is no indication of their response to other organic insecticides. Despite the sensitivity of certain plants to DDT many others appear to be tolerant. However, plants are less tolerant to BHC than to DDT. Boswell (U. S. D. A. Yearbook pp. 284-296, 1952) reported that Honey Dew melons were especially sensitive to BHC, whereas strawberries appeared to be tolerant. Germination of a large number of plant seeds was inhibited when they were coated with BHC or left in contact with it in the soil even where dosages were light—1 to 6 pounds of technical BHC per acre. Technical BHC in soil at 3 p.p.m. was harmful to red clover, soybean, and vetch, and at 30 p.p.m. caused serious injury. At 50 pounds per acre BHC was harmful to most crops grown in the soil the year it was applied, but was not harmful to cotton or tobacco grown the following year. Applications of 100 to 200 pounds of technical BHC consistently ruined the plantings of test crops.

While BHC has not been widely recommended for use as a soil insecticide, Dawson *et al.* (Agr. and Food Chem. 1:399-403, 1953), Gilpin and Geissenhainer (Food Technol. 7:137-138, 1953), Stitt and Evanson (Jour. Econ. Ent. 42:614-617, 1949), Greenwood (1947) and others showed that the presence of BHC in the soil is likely to cause off-flavor of vegetables, especially root crops, sometimes resulting in a complete loss. Owing to its tendency to cause off-flavor, BHC should never be used on soils in which potatoes, sweet potatoes, carrots, beets, other root crops or peanuts are to be grown. Off-flavor in tomatoes and lima beans also occurred where BHC was used. Allen *et al.* (U. S. D. A. Tech. Bul. 1047, 1951 and U. S. D. A. Tech. Bul., 1953—at press) showed that when applied to the soil, both BHC and toxaphene caused off-flavor in tobacco that is objectionable to cigarette manufacturers. Annual light dosages were more objectionable than heavy dosages that had leached for 6 years.

Boswell (U. S. D. A. Yearbook pp. 284-296, 1952) reported that lindane, the gamma isomer of BHC, has little, if any, harmful effect on germination, although it tends to be about as toxic to later growth of plants, pound for pound, as BHC. However, it is less likely to cause off-

flavor. Gould and Hamstead (Jour. Econ. Ent. 44:713-717, 1951) showed that BHC applied to peach and apple replants appeared to stimulate their growth, if it did not come in direct contact with the tender rootlets. At the same time it reduced weed growth.

In tests made by Allen *et al.* (U. S. D. A. Tech. Bul. 1047, 1951) increased yields of cowpeas also followed the use of BHC. Stimulation of growth on these crops where BHC has been applied to the soil cannot be accounted for in its entirety. These investigators believe it is due to improved control of weeds, and of root aphids, nematodes, and certain other soil organisms, although available data have not always borne out these possibilities.

Stone *et al.* (U. S. D. A. Cir. 926, 1953) reported that toxaphene reduced yields of Fordhook lima beans, celery, carrots, and potatoes after three annual applications at 20 pounds per acre. Potatoes grown in this soil were off flavor. Fleming *et al.* (Bur. Ent. and Pl. Quar. E-829, 1951) showed that more than 50 percent of the initial deposits of toxaphene in the soil were lost after 40 months. At this rate of breakdown excessive residues of toxaphene when applied at the present recommended dosages seem unlikely.

Chlordane was not so persistent as DDT in soils treated for Japanese beetle control as reported by Fleming *et al.* Only 30 percent of the chlordane remained in turf treated with 10 pounds per acre after 1½ years of weathering. Accumulations in the soil except in orchards would probably be slow. Chlordane at high concentrations will reduce the germination of certain seeds as evidenced by its recommendation for crab grass control at 10 pounds per acre prior to the time of sprouting. Investigators have found that many plants, including strawberries, that are adversely affected by DDT, are highly tolerant to chlordane. Off-flavor has been reported in root crops treated with chlordane, but it is not general.

Aldrin breaks down rapidly when applied to soil. Fleming *et al.* also reported that only 33 percent remained after 1 year. Stone *et al.* (U. S. D. A. Cir. 926, 1953) reported off-flavor in potatoes grown in soil treated with aldrin, an indication that it may cause off-flavor to certain root crops.

Dieldrin is less likely to break down in soils than the organic insecticides previously discussed, except DDT. Fleming *et al.* (Bur. Ent. and Pl. Quar. E-829, 1951) reported that 67 percent remained in the soil after 1 year. Data on the toxic effects of dieldrin on plants are still limited, owing to its short period of use. Off-flavor in root crops does not seem to be a problem where dieldrin is used.

Isodrin, endrin, methoxychlor, and Strobane have not been tested extensively enough to secure reliable information as to their accumulation in the soil or their effects on plants.

Fahey *et al.* (Jour. Econ. Ent. 45:700-3, 1952) have demonstrated that EPN, the most stable of the organic phosphorus insecticides, disintegrated within 3 months. Any plant injury occurring from the use of TEPP, parathion, EPN, malathion, and Diazinon is caused by direct contact and is not long lasting.

Studies on the effects of organic insecticides on soil organisms have been limited. Wilson and Choudhri (Jour. Agr. Res. 77:25-32, 1948) found

that BHC killed certain soil algae and urea-decomposing micro-organisms but had no effect on nitrogen-producing bacteria and fungi. Jones (Utah Agr. Expt. Sta. Farm and Home Sci. 11:58-59, 1950) found that ammonifiers that break down organic matter were affected by DDT, chlordane, and BHC at concentrations above 0.1 percent, but that nitrogen-fixing organisms were unaffected. According to Gould and Hamstead (Jour. Econ. Ent. 44:713-717, 1951) arthropod populations were heavily reduced where BHC and chlordane were applied to the soil at comparatively high concentrations in young peach and apple plantings in West Virginia. DDT was less toxic to arthropods than the other two insecticides. Treatments of soils with organic insecticides do not appear to affect seriously the normal functioning of the micro-organisms.

The following facts relative to the effects of organic insecticides on soils and plants are apparent from present knowledge: the dosages normally recommended are not generally high enough to result in immediate buildup of residues that may be detrimental to the growth of crops, except in orchards where high dosages are applied annually. Certain organic insecticides, especially DDT and dieldrin, are highly stable in the soils and at high dosages, perhaps the 100-pound level, may reduce some crop yields. This is especially likely where shallow rooted plants are present, since the accumulated residues remain close to the surface and are carried into the soil only by cultivation. Certain organic insecticides cause off-flavor in root crops grown in soils treated with them, particularly BHC even though used in small amounts. New insecticides must be carefully screened to avoid soil contamination with such insecticides. No single factor has contributed to the greatness of America more than her fertile soils which at all times have assured adequate food for all her inhabitants and allies. It is our duty to protect this productivity by the development and use of non-accumulative insecticides and by limiting recommendations to as light dosages as possible. Whenever certain plants cease to grow or develop, we cannot move to virgin soils, as was often done during the pioneer days of our country.

Effects on Human Health. JOHN V. OSMUN, Department of Entomology, Purdue University.—This is a symposium on the effects of continued use of our newer insecticides, and stated as such, there is an implication that possible hazards exist. We all recognize the good derived from the use of insecticides, but it is well to take stock of what adverse situations may accompany their use, and be alert to toxicological areas that need continued investigation.

The problem of human hazards associated with insecticides is not a new one, but it has grown more serious with the advent of synthetic organic insecticides (Hayes: Advan. Chem. Ser. 1:56-60, 1950). This situation arises from the fact that these insecticides are more widespread in their use, are varied in their physiological mode of action, and by their very chemical nature, are often difficult to utilize properly within the bound of desirable exploitation. Numerous papers have been prepared in recent years on the real and potential effects on human health. Some of them are based on reliable experimental and observational data, while others have been perpetrated by scare mongers and political aspirants.

If mammalian toxicity is a consideration, the value of the insecticide must be a relative thing. A decision must be made between the value of the insecticide in terms of preserving crops and protecting human life, and the possible jeopardy to the health of those applying the material and others who may directly or indirectly be exposed to it. It is the latter problem with which we are concerned in this part of the symposium.

Organic insecticides can adversely affect human health both as acute and chronic poisons. Although the acute poisonings are more spectacular and usually remembered, it is chronic poisoning with its insidious actions that probably presents the greater hazard. None of the organic insecticides are entirely free of toxicology problems, but for illustration, only a few representatives of different chemical groups will be mentioned here.

1. Acute Toxicity Problems

Most of the synthetic organic insecticides now in use are less acutely toxic than many of the older materials such as nicotine, the arsenicals, or sodium fluoride. Acute poisoning in man has resulted, however, from excessive dermal and oral exposure to organic insecticides.

DDT has not been known to cause acute poisoning in routine use, but Barnes (Bull. World Hlth. Org. 8:419-490, 1953) reports several cases apparently resulting from accidental poisoning. In these cases, dizziness, weakness, and irritability were noted, followed by convulsions and sensory disturbances of the limbs. Such severe exposures usually produce visible changes in the liver and sometimes other tissues.

Parathion, which possesses unusual and severe toxic properties due to its ability to inactivate chlolinesterase, is one of the most acutely dangerous products in common use. Either single heavy exposure or a succession of smaller exposures may lead to intoxication. The application of such insecticides by unprotected personnel has resulted in sickness after absorption through the skin, swallowing, and inhalation (Hamblin and Golz: Amer. Cyan. Co. 1953). The latter is not a vapor toxicity problem according to Barnes (Barnes: 1953), but one of dust and fine particle intake into the respiratory system. It must be noted that many insecticides penetrate undetected and without irritation (Hamblin and Golz: 1953). Examples of such poisoning have been recorded among some workers hired to harvest pears and grapes (Barnes: 1953). Contact occurred as the men worked through the previously sprayed foliage. Although parathion is in a class by itself, it serves to illustrate the potential acute hazards associated with continued use of the newer toxic insecticides.

2. Chronic Toxicity Problems

Many of the synthetic organic insecticides are to some degree chronically toxic. The great problem arises from our inability to detect such occurrences and to know at what levels the insecticides are chemically dangerous. Any of us, whether we work with insecticides intimately or contact them as unobtrusively as does the layman, may possess symptoms of chronic toxicity. Such effects might be slight, as manifested by an allergy; others could be more pronounced. The effects of some minimal exposures may not be apparent for years to come.

It is the repeated contact of the body with small dosages of the synthetic organic insecticides which causes chronic poisoning. Such exposure may occur to those applying the insecticide, to anyone inhaling the vapor, to laborers working with products and plants that have been insecticide-treated, and to people consuming food that still bears traces of the chemical.

Although the first method of contact is an obvious one, it is also a difficult one to prevent. Even trained personnel tend to get careless when spraying or dusting since no immediate adverse effects are noticed, and little thought is given to a material spilled on hands or clothing. Intake by inhalation of vapors is restricted to a few insecticides, one of which is lindane. Lindane electric vaporizers are common today, and although this insecticide is not stored in the body, it is considered hazardous to inhale repeated quantities of the material (Conley: Jour. Amer. Med. Assoc. 149:367-369, 1952). As J. R. Wilson (Paper, Amer. Chem. Soc. 1952) of the Council of Food and Nutrition so aptly put it, "It is highly questionable whether one man has the right to contaminate another man's air." With the exception of the organic phosphates, few of the newer organic insecticides are readily absorbed through the skin.

One of the primary problems today is that of insecticide contaminated food. Although no evidence exists that small quantities of insecticides in common use have produced any recognized poison symptoms or tissue changes in man, no one can yet say that ingestion of small quantities of DDT or other insecticides over the life-span of a man is entirely harmless. Although generally considered remote and at present without foundation, carcinogenic growth is a possibility resulting from adverse stimulation of body tissues. DDT in small quantities is frequently ingested along with food which has been previously exposed to the insecticide (Barnes: 1953). Storage is in fat. Although presence in fat is not necessarily an indication that a material is better able to produce chronic toxic effects, the very presence in the system is potentially hazardous, especially if a person were to draw suddenly upon his fat reserve. It is difficult to escape repeated exposures of insecticides.

It is notable that no Federal residue tolerances have been set on the new synthetic organics. There has been a tendency to criticize the Food and Drug Administration for this, but it must be remembered that there is no sure physiological study which will reveal the long range possibilities of chronic poisoning. In man, the situation superficially seems encouraging, but on the other hand, injury has been significant with repeated exposures in laboratory animals. Too liberal a tolerance could be a serious mistake.

It would seem that considerable promise can be expected with the thoughtful development of new materials. The remarkable development of malathion, for example, points the way to chemicals which are safer from the standpoint of mammalian toxicity, while still potent insecticidally. Residue problems can be decreased not only by improved chemicals, but by changes in the adjuvants which go into formulations, and by properly timed applications.

There has been a tendency in this paper to place the emphasis on the hazards created by new insecticides from the human health standpoint. This is justifiable not only in view of the topic assigned, but because of the lack of critical information on many of the toxicology problems. It is not that fear should stem from ignorance, but rather that intelligent precautions and thorough investigations should accompany the introduction of any chemical that finds its way to men as frequently as does an insecticide. There is no doubt that insecticides have proved a great value both in the control of insect-borne diseases and in the protection of crops. It remains only to achieve a proper balance between this value and the maintenance of the health of our nation.

GEOLOGY AND GEOGRAPHY

Chairman: CLIFFORD ADAMS, Hanover College

BENJAMIN MOULTON, Butler University, was elected chairman for 1954

ABSTRACTS

Identification of Indiana Coal II by plant spores.[1] G. K. GUENNEL, Geological Survey, Bloomington, Indiana.—Spore analyses of six samples, tentatively identified as Coal II, were made in order to determine whether: 1) Coal II could be identified on the basis of spore assemblages; 2) Coal II could be distinguished from the coal seams above and below the Coal II horizon; and 3) Coal II could be correlated on the basis of miospore assemblages with its equivalent in Illinois.

Percentages of spore genera were derived and converted to bar graphs for easy comparison. Species also were recorded. Since the graphs and species lists were remarkably similar, the six samples were verified to be of the same age. The data then was compared to similar data derived from analyses of samples of Coal III and the Minshall coal, which lie above and below the Coal II horizon respectively. This comparison proved that the spore assemblages of Coal II could be distinguished from those of Coal III and the Minshall.

An examination of Coal II statistics and published data of Illinois coals of approximately the same stratigraphic position showed a similarity between Coal II and the DeKoven-Greenbush and Davis-Wiley seams of Illinois.

The petrology of the Block underclays in west-central Indiana. HAYDN H. MURRAY and SAMUEL L. RIELY, Indiana University.—The underclays of the Upper and Lower Block coals occur in the Brazil formation of Pottsville (Pennsylvanian) age. The Upper Block underclay is utilized extensively in Clay and Parke Counties as the raw material in the manufacture of structural clay products in the vicinity of Brazil, Indiana. The Lower Block underclay is used very sparingly because operators claim that its ceramic properties are poor. The purpose of this study is to determine if a relationship exists between physical properties and petrology. The petrologic study of these two underclays involved detailed field studies; differential thermal, X-ray powder diffraction, and chemical analyses; microscopic identification; and pipette analysis. Kaolinite, illite, chlorite, and quartz comprise approximately 95 percent of the minerals in the underclays. Pyrite, limonite, siderite, magnetite, tourmaline, garnet, and rutile were observed in the sand and silt fraction. Three zones are recognized in these underclays in the field: an upper leached zone, a middle nodular zone, and a basal clay-shale zone. The underclay in the upper leached zone has the best ceramic properties and is thickest in the Upper Block underclay.

Other fundamental petrologic characteristics are discussed in relation to the economic usage of these underclays.

1. This paper is presented with permission of the State Geologist, Indiana Geological Survey.

Wholesaling in metropolitan areas of the United States. JACK C. RANSOME, Indiana University.—In 1948 fourteen metropolitan areas contributed 50 per cent of all United States wholesale sales. A complete correlation fails to exist between the magnitude of population and the rank of an area in wholesaling. Four metropolitan areas have higher per capita sales and eight areas have a higher percentage of their employed population in wholesaling than New York City. Inconsistencies between the population size and rank in wholesaling are the result of many factors—wholesale distribution radius, transportation concentration, volume of foreign trade, value of goods handled, the emphasis placed upon wholesale distribution relative to the emphasis upon other metropolitan functions, and the proximity of competing centers.

In all wholesaling areas there is a fairly close relationship between processing activities and the major commodities distributed. Highly refined marketing procedures accompany the increasing specialization in commodities. Such specialization is most marked as metropolitan centers increase in size, and when they serve as assembly and distribution points for primary materials.

All major wholesaling centers have favorable sites and situations which have given them a comparative advantage over competing centers. Competition tends to space the largest wholesaling centers about 100-400 miles apart, the spacing being somewhat greater in the South and the West than in the East and the Midwest.

Wisconsin stratigraphy of Central and Eastern Indiana.[1] WILLIAM J. WAYNE, Indiana Geological Survey.—The Wisconsin stage in Indiana consists of three recognizable stratigraphic units that are separated from each other by fossiliferous interstadial deposits. The oldest of these tills is the most extensive, and its southern limit constitutes the Wisconsin boundary. Soil profiles on it contain several inches of loess-like silt in the "B" horizon. Comparatively little outwash is associated with the till except along the Wabash Valley where outwash of this age forms the highest level of valley fill.

The ice withdrew from central Indiana during the first Wisconsin interstadial, and during the subsequent readvance deposited the second stratigraphic unit. Generally, the outer limit of this second till is a few miles north of the margin of the earlier substage, and in many places it coincides roughly with the Bloomington moraine. Extensive, thick gravel deposits overlain by till characterize this second stratigraphic unit throughout northern and central Indiana. In many places this till overlies loess and lacustrine deposits that contain mosses, twigs of conifers, and molluscs in the upper few inches, but a true buried soil has not been found.

These two drift layers have long been correlated with the Tazewell substage of Illinois, mainly on the basis of presumed correlation of moraines. East of the interlobate area along the Wabash Valley, however, the relationships of the successive moraines may not be the same as in

1. Published with the permission of the state geologist, Indiana Department of Conservation, Geological Survey.

Illinois, and it is possible that the older till is Iowan and the younger till Tazewell in age.

The third Wisconsin stratigraphic unit belongs to the Cary substage and is separated from underlying deposits by fossiliferous silts and clays, peat deposits, or leached zones. The Mississinewa moraine marks the farthest advance of the ice during the Cary subage in northeastern Indiana, but farther south the ice extended beyond this moraine. Cary till contains more clay than do the two earlier tills, which are silty and bouldery. The higher clay content of the Cary till probably resulted when ice of the Erie lobe moved over lacustrine deposits that had accumulated during the Tazewell-Cary interval in ice marginal lakes similar to those that later in Pleistocene time evolved into the present Great Lakes.

The Restoration of the Structure of Degraded Soil. DAVID TELFAIR and MURVEL R. GARNER, Earlham College.—The factors in restoring structure and porosity to soils degraded by puddling and compacting are considered. Prepared cylinders of puddled soil were buried in (a) a cultivated garden (b) a fallow field and (c) a dense forest. Cylinders were exhumed at intervals for the study of restoration processes.

After two years relatively minor changes had taken place, the slightest changes occurring under the forest cover. In the cylinders buried in a fallow field roots had entered into all parts after two years.

The physical and biological factors involved in the restoration processes are considered. Later modifications of the experiments are described.

Cities and Towns of Indiana Geographically Considered. STEPHEN S. VISHER, Indiana University.—Geographic conditions conspicuously influenced the location and development of most of Indiana's concentrations of population. In the earlier decades, most of these were villages or towns. No place attained a population of 10,000 until the 1850's; not until 1890 did Indianapolis have 100,000, and Evansville 50,000 and five others 20-35,000. But now Indiana has many sizable cities. Factors affecting the location of the cities were waterhighways, waterpower for mills, crossings of roads, crossings of rivers by roads, and later by railways; railway intersections. The proximity of good agricultural land and of minerals have also been important. A highly significant influence was also the county seats, generally situated near the center of the county.

Four easily recognized regions as to cities are: 1, the Ohio River Belt; 2, the Gas Belt, in which several towns grew into cities shortly after the discovery of gas in the 1880's and 1890's; 3, the Coal Field, in which there are several cities which grew up chiefly after the coming of railways accelerated coal shipments; and 4, cities of Greater Chicago and somewhat east thereof. These were predominately influenced by railway transportation but Lake Michigan conspicuously affected several. The remainder of the state, region 5, contains the largest city and Ft. Wayne, but otherwise chiefly only small cities whose location and growth reflects especially the conditions mentioned in the previous paragraph.

Township boundaries in Indiana. ROBERT GUILFORD TAYLOR and OTIS P. STARKEY, Indiana University.—One-quarter of the present civil townships have boundaries coinciding with the Congressional township boundaries while only 15 per cent of the townships have boundaries unrelated

to the Congressional Survey. The conformity between the two types of townships is greatest in the northeast and least in the south. Streams are the outstanding cause of departure from the Congressional or township-range system of survey. Oversized or undersized townships created to fit irregular county boundaries explain many partial unconformities. The location of early roads and land grants, mergers in sparsely settled areas, splittings in densely settled areas, and townships created to coincide with municipal units, account for most other departures.

Chester rocks north of the East Fork of White River, Indiana.[1] T. G. PERRY and G. T. MOORE, Indiana University.—Rocks of lower and middle Chester (Upper Mississippian) age crop out north of the East Fork of White River in north-central and northeastern Martin, northwestern Lawrence, the eastern one-third of Greene, central and eastern Owen, western Monroe, and south-central Putnam Counties. Pre-Pennsylvanian erosion removed progressively older Chester formations at increasing distances north of the East Fork of White River. Consequently, the Beech Creek limestone (youngest formation of the lower Chester group) does not crop out in Putnam County, and the Cypress sandstone and the basal portion of the Golconda formation are the only middle Chester rocks in southern Owen County. Although the regional west and southwest dips commonly range from 25 to 40 feet per mile, altitudes on closely spaced Beech Creek exposures indicate that many subdued structural anomalies, such as basins, domes, and arches, are superimposed on the regional structure. Only two lower Chester formations, the Paoli limestone and the calcareous facies of the Aux Vases formation, are presently quarried, and in every case these are mined with the Ste. Genevieve limestone (upper Meramecian). Many inhabitants of rural Indiana depend solely upon springs associated with Chester limestones for their water supply. (Since this paper was presented, Messrs. Gordon and Shepherd have begun quarrying operations in the Beech Creek limestone at a site near the West Fork of White River, about 4 miles south of the village of Freedom, in Owen County.)

Modern floodplain deposits. CLIFFORD ADAMS, Hanover College.—Modern deposits are defined as those accumulating since the introduction of present day agricultural methods. They can be identified commonly as light colored, stratified silts above old soil profiles. The latter typically reveal dark, unstratified soil underlain by lighter subsoil.

Some slides showing the sharp break between the two soils and cross-sections illustrating the ancient and new surfaces are shown. Comparisons between representative valleys of different drifts and unglaciated areas are presented.

Occasionally a pebble band is found just above the old soil horizon. No significant difference has been revealed by mechanical analyses of the new and old soil.

The recent soil varied considerably in depth but most frequently is found to be two to three feet in thickness. This accelerated sedimentation in valleys may profitably be pointed out in introducing man as a geological agent.

1. Presented with permission of the State Geologist, Indiana Geological Survey.

Ground water potential in local upland sand deposits in Southeast Indiana. PORTER E. WARD, U. S. G. S.—On the uplands of southeast Indiana in areas covered by Illinoian glacial drift, ground-water problems are acute. Recent investigations of upland areas confirms the existence of local water-bearing deposits of limited extent that are utilized as sources of water. These deposits generally are shallow and lie close to or on the top of the bedrock. Thicknesses are variable, the average observed being not more than 10 feet. Known deposits consist mainly of fine sand and gravel which may or may not be overlain and underlain by clay or clayey sand.

The potential of these deposits is variable. Differences in occurrences have been observed, such as character of materials deposited, thickness and lateral extent of deposits, and conditions of recharge, storage and discharge.

Although water-bearing, these deposits have definite limitations. This is illustrated by the failure of wells at Milan in Ripley County to produce, at a constant rate, sufficient water from a local occurrence of sand for a public water supply.

Additional studies are needed of the geologic occurrence and hydrologic character of these upland sand deposits in order to fully understand and evaluate their use as sources of available ground water.

A Regional treatment of the agricultural geography of the Calumet Region. ALFRED H. MEYER, Valparaiso University.—About a quarter century ago Edward Duddy made an agricultural study of the Chicago Region which included the Calumet area to the southeast. This was one of the Social Science studies directed by the Local Community Research Committee of the University of Chicago. Data of U. S. Census of Agriculture for 1925 were used to show areal farm values and productivity.

Our present study analyzes the agriculture scene on a geographical or regional basis, using both statistical data of the U. S. Census for 1945 and personally mapped field transects.

Six agricultural regions are differentiated on the basis of landform, soil, vegetation and land-use—two on the Chicago Lake Plain, three on the Valparaiso Moraine and the remaining one constituting part of the Kankakee Outwash Plain. The agricultural patterns of each are examined and evaluated in relation to their major geographic correlations and problems and their relationships to the conurbanized area on the southwest end of Lake Michigan, which has almost exclusively industrial, commercial and residential functions.

The geographical regional analysis of the agricultural patterns and problems of the Calumet suggests the desirability of the establishment of conservancy districts to effect proper soil conservation practices.

To resolve and reconcile the competing agricultural and non-agricultural forms of land-use, county planning commissions should be set up in all counties and their programs should be integrated with one another on a regional geography basis. This might best be managed by inviting the Chicago Regional Planning Association to include the farming program of the Calumet in their regional planning objectives.

Clastic Rocks Near the Chester-Meramec Contact in Putnam County, Indiana

C. L. Bieber, DePauw University

General.—It is difficult to place the contact between rocks of Meramecian and Chesterian age in Putnam County because a massive limestone sequence, exposed in the south half of the area, is only locally interrupted by significant changes in lithology. The boundary may be marked by sandstone or shale, but as a rule this stratigraphic interval is either covered or poorly developed. The sandstone, if present, is generally calcareous and fine-grained. Inspection with a lense reveals the sand. The sandy limestones and calcareous sandstones that commonly make up the cross laminated Rosiclare member of the Ste. Genevieve formation are confusing because they may be within a few feet of the Paoli limestone. Aux Vases shale and sandstone, mostly of green-gray color, are rarely recognized and of limited use as a marker at the Ste. Genevieve-Paoli break.

Criteria for Recognizing the Chester-Meramec Contact

Stratigraphic sequence.—Massive limestones of the Ste. Genevieve-Lower Chester interval are so uniform lithologically that an examination at the outcrop should be made to attempt to locate markers above and below. The upper St. Louis limestone is mostly thin-bedded, cherty, and rich in bryozoans. *Lithostrotion proliferum* is sparsely scattered throughout. *Lithostrotionella canadense* is in a zone of massive limestone a few feet above the thin cherty beds. If the section goes low enough the gray-blue St. Louis cherty beds provide a known horizon.

The massive gray Ste. Genevieve limestone beds above the St. Louis limestone are 50 feet to 60 feet thick. Paoli limestone ranges from 0 to 12 feet thick, and may rest directly upon massive Ste. Genevieve limestone. Thus to find the Chester-Meramec contact, the Mooretown shale and Beaver Bend limestone above should be located, if present, and used as a guide.

Two typical sections that include the contact are given.

3 miles southwest of Greencastle, in the SW¼NW¼ sec. 36, T. 14 N., R. 5 W.

Mississippian

	Feet
Paoli limestone	
7. Limestone, light-gray, oolitic in part, conglomerate in center; small brachiopods	10
Aux Vases? formation	
6. Sandstone, buff, medium-grained, white and calcareous upward	4
5. Covered, shale in part	6
4. Sandstone, light buff to white, calcareous	1
3. Shale, sandy, greenish	0.5

Ste. Genevieve limestone

2.	Limestone, fine-grained, gray, brecciated and mottled above (Bryantsville)	2.5
1.	Limestone, massive, gray	17.5
	Covered	

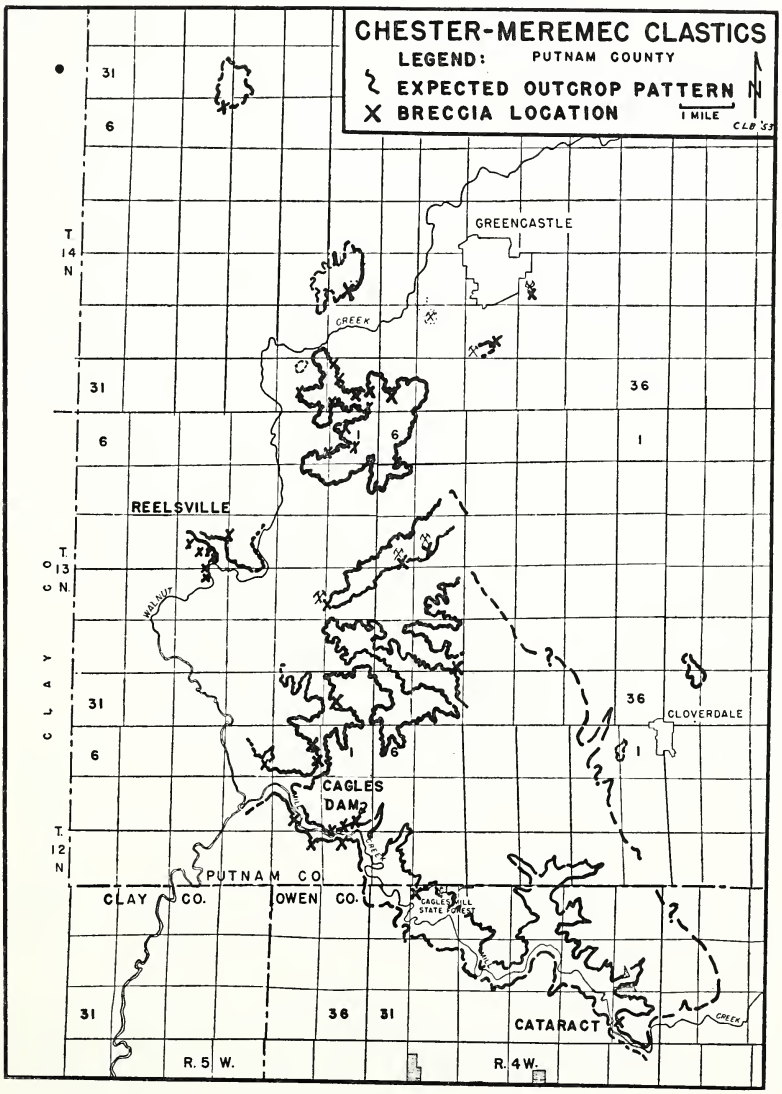
Lone Star Cement Quarry, 2 miles south of Greencastle, SE¼SW¼ sec. 28, T. 14 N., R. 4 W., Putnam County.

		Feet
	PLEISTOCENE	
18.	Glacial drift, buff above, gray below	10
	PENNSYLVANIAN	
	Mansfield formation	
17.	Shale, dark gray	1
	MISSISSIPPIAN	
	Paoli? limestone	
16.	Limestone, oolitic, white, iron stained on top	4
15.	Limestone, gray, fine crystalline	3
14.	Limestone, gray, crystalline, carbon spots below	5
13.	Shale, siltstone, fine sandstone, gray, with limestone lenses; small brachiopods; charcoal-like inclusions	10
	Aux Vases? formation	
12.	Shale, black, finely laminated	3.5
11.	Shale, medium gray, blocky, pyrite common	1.5
	St. Genevieve limestone	
10.	Limestone, nodular, brecciated, mottled, weathered greenish clay (Bryantsville)	1
9.	Limestone, gray, dense, crystalline	4
8.	Limestone, shaly, gray-green, fossiliferous	4
7.	Limestone, gray, dense, thin bedded	2
6.	Limestone, dark gray, fine grained, brecciated near the top	4
5.	Limestone, gray, crystalline, massive	6
4.	Limestone, gray, massive, cross-bedded, oolitic, rounded grains of chert sand (Rosiclare)	12
3.	Limestone, gray, massive, crystalline	18
	St. Louis limestone	
2.	Limestone, gray with shaly parting above, *Syringopora* and *Lithostrotionella canadense* scattered with the bedding	3
1.	Limestone, thin bedded, cherty, bryozoa and sperifer-oid brachiopods common	6
	Quarry floor	

Breccias and conglomerates.—The most persistent zone of limestone breccia is at the top of the Ste. Genevieve formation. This breccia correlates with that exposed in the vicinity of Bryantsville in Lawrence County. The horizon has been traced from the Ohio River northward into west central Indiana (3). In Putnam County the angular limestone fragments of the breccia vary in color from medium dark-gray to nearly black, and are commonly sublithographic. The most characteristic Bryantsville brec-

cia is found in or associated with fine-grained limestone. The zone often overlies massive crystalline beds. The bedding in the brecciated zone is mostly irregular and undulating, and may wander vertically in seams for as much as 3 to 5 feet. Finely laminated limestone is sparingly present. The rock of the breccia is commonly all limestone though sandy limestone occurs.

Oolites are rare to plentiful. Locally greenish calcareous sandstone is included in the matrix. Weathering of the horizon produces a nodular rubbly limestone with sparse amounts of greenish clay. Examples of this



type of Bryantsville is at Upper Cataract Falls in Owen County (1), and along Maiden's Branch 1 mile north of Reelsville in the NW¼SE¼ sec. 16, T. 13 N., R. 5 W.

Other brecciated and conglomeratic zones lense in and out locally through the Ste. Genevieve and less commonly in the Paoli. Conglomerate made up of whitish flat limestone pebbles ranging in diameter from one-half inch to about one inch is rather common in the cross-laminated beds of the Rosiclare member of the Ste. Genevieve limestone. This conglomerate and breccia may be 10 or more feet below the Bryantsville breccia. Even more complex are the conglomerates and breccias in the exposures at the west end of the tunnel at Cagles Mill Dam in the NW¼ sec. 13, T. 12 N., R. 5 W.

Sandstones.—The most persistent sandstone in the St. Genevieve-Paoli sequence is the Rosiclare (middle) member of the Ste. Genevieve formation. The rock of this massive member ranges from an oolitic or non-oolitic limestone to a calcareous sandstone. The sand grains vary from fine to coarse and are composed of clear frosted quartz and chert. Tiny sand grains form some of the nuclei of oolites. Sand grains are commonly scattered, but tend to concentrate where cross bedding is prominent. The Rosiclare member usually exhibits cross bedding.

Above the Rosiclare member, and associated with the Bryantsville breccia are locally lensing calcareous sand beds. The layers are at the approximate Aux Vases (lowest Chester) interval. Thickness of these local sand lenses range up to about 5 feet. Color is from greenish-gray to white. The local sand layers are either above or below the Bryantsville breccia. The sandstone of the lowest Chester horizons is composed of fine subangular quartz grains.

A typical sample sieve analysis of the Aux Vases? sandstone located 3½ miles southwest of Greencastle in the SW¼NW¼ sec. 36, T. 14 N., R. 5 W. is given.

Mesh size	% of total sand
50	18.0
60	4.8
70	4.9
80	11.6
120	28.0
200	17.6
pan	12.8
	98.6

A heavy mineral study (4) shows that minerals above 2.9 in specific gravity make up slightly less than 1 percent of the sandstone by weight. Heavy minerals most frequently present are leucoxene and zircon. Those less common are tourmaline, rutile, ilmenite, and brookite.

Shale.—Notable shale is not present immediately below the Chester-Meramec contact, though the upper Ste. Genevieve limestone has local shaly facies. Dark gray to greenish shale (Aux Vases?) with associated

calcareous sandstone is locally present above the Bryantsville breccia. The dark shale, when present, is easily confused with the Mooretown shale above the Paoli limestone, especially since the Paoli-Ste. Genevieve forms an almost continuous limestone sequence. One of the best exposures of the shales near the contact is in the wall of the Lone Star Cement Quarry 2 miles south of Greencastle (see section). The prominent upper shale is here interpreted as the equivalent of Aux Vases (lowest Chester). An earlier study is not in agreement (2).

Use of fossils.—Fossils are not plentiful in the massive limestones. They are mainly brachiopods of productid and spirifer type, spines of echinoids, and fragments of blastoids and crinoids. Of these, the stem fragments of *Platycrinus penicillus* have been used as a marker for the Ste. Genevieve formation. There is some doubt as to the stratigraphic reliability of the fossil, however. These oval sprocket-like stem fragments are not common nor easily discovered on exposures in Putnam County. Columnals with petal-shaped centers are of some worth as guides for upper Ste. Genevieve and lower Chester limestones.

Other means of locating the contact.—Insoluble residue studies help in locating the siliceous horizons which are near the Chester-Meramec contact. Cross bedding and ripple marks are most common in the Rosiclare member of the Ste. Genevieve limestone. The cross bedded zones of the Rosiclare interval commonly carry sand grains. Paoli limestone cross beds are present to rare, and bear sand sparingly.

The mapping of sink holes has been found helpful in locating the general horizon of the clastic rocks. There are few sinkholes in the Salem of Putnam County, relatively few in the St. Louis, but they are common and large in the area of outcrop of the Ste. Genevieve-Paoli limestones. The line of contact of the present study is associated with the western margin of the main sink hole pattern.

Summary.—Calcareous sandstones, shales, breccias, and conglomerates of Chester-Meramec time were probably formed by currents and storm waves carrying sand and mud into comparatively shallow seas where limestone was forming. Off-lap and on-lap may account for apparent reversals in sequence, and for lensing of sands and breccias. Some of the clastic rocks may have been destroyed by pre and post Chester erosion but evidence of widespread unconformity between Meramecian and Chesterian rocks in Putnam County is vague. Future drilling should aid in the correlation of dark shales near the contact.

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Classifying the Earth Science Collection

S. M. McClure and Floy Hurlbut, Ball State Teachers College

The Earth Science Division of the Science Department of Ball State Teachers College has been collecting earth science materials for some years. A few years ago an additional collection was purchased with funds from the Ball Foundation. It was purchased from Mr. William H. Schrawder, a former teacher in the Schenley High School in Pittsburgh. He had spent his summers for many years travelling and collecting. During the winter, his recreation was cutting, shaping, polishing and classifying. The total was purchased in two groups and stored until this summer for lack of space. The completion of the new Practical Arts Building this summer relieved the space on third floor of the Science Hall for expansion, and we are in the process of arranging the total collection in museum cases, and for use in teaching.

The Schrawder collection included, besides earth science materials, specimens from the fields of archeology, conchology and many manufacturing processes. There were about 1,090 specimens which we added to the original collection belonging to the college, making a total of about twelve hundred specimens.

Of the new collection 69 were listed as museum specimens, 136 as teaching materials. There were 230 minerals, 107 igneous rocks, 95 metamorphic rocks, and 90 sedimentary rocks. In the fossil group, 66 were plant fossils, 105—invertebrate fossils, and 63 vertebrate fossils.

The first step was the separation of the earth science material from the conchology specimens and from those representing manufacturing processes. The latter two groups, consisting mostly of shells and alloys, were turned over to the divisions of biology and chemistry, respectively.

The earth science specimens were divided into four large groups, the first containing museum and teaching materials, the second, the minerals, the third, the rocks, and the fourth, the fossils. The last named was further subdivided into plant, invertebrate animal, and vertebrate animal fossils.

After consultation with geological authorities at Washington University (2), Northwestern University (3), Harvard (4), and the Field Museum (5), it developed that there was no one accepted method of classifying a geological collection and the lack of such a system allowed the authors to devise one for the classification.

Since it was thought best to identify each specimen by a number, an effort was made to express some significance in the number. Accordingly, six divisions were designated by numbers; those from one thousand to 1999 were assigned to the museum specimens and teaching materials, the two thousands to the minerals, the three thousands to the rocks, the four thousands to the plant fossils, the five and six thousands respectively to the invertebrate and the vertebrate fossils.

The teaching materials were further subdivided into sections with the geological agents as the basis of subdivision. Thus the ten hundreds were reserved for the museum specimens and the teaching materials

showing the effects of weathering, the eleven hundreds for the work of the atmosphere, the twelve hundreds, the effects of running water, the thirteen hundreds, the work of the atmosphere, and the fourteen hundreds, the specimens from lakes and swamps. Glaciation, marine action, structure, diastrophism, vulcanism and miscellaneous specimens rounded out the ten division. Arbitrarily selected numbers within the division indicated the various individual specimens.

The second group, the minerals, presented more of a problem. The Dana system, long honored basis for the numbering of minerals, was being discarded for a new series being worked out by the Harvard revisers of the textbook. The new system had not yet appeared when the work of classification was started, so the authors, on the advice of Professor Palache (4), simply took the chemical groups of minerals as listed in Hurlbut's (6) text, reduced them to ten groups by combining the carbonate group with the borates and nitrates, and arbitrarily assigned numbers within the various groups to include all the minerals listed by Hurlbut. Thus calcite is given number 2501; the number 2000 indicates that it is a mineral, the 500 in the figure refers to the carbonate group, and the one is the number assigned to calcite. Aragonite is numbered 2551 while dolomite is 2511.

Silica is included with the silicates and an attempt, not entirely successful, was made to follow Berman's classification of this group (7).

The rocks were subdivided into three instead of ten classes; the usual subdivisions of igneous, sedimentary, and metamorphic groups were used. These were numbered, respectively, thirty-one hundred, thirty-two hundred, and thirty-three hundred. Numbers within these ranges were assigned arbitrarily to the individual rocks; thus granite is 3101 followed by twenty-one varieties of igneous rocks. In the sedimentaries, sandstone is 3214 and in the metamorphic series, marble is numbered 3368.

The fossils are also grouped into three major divisions. Plant fossils were assigned the four thousands, invertebrate animal fossils, the five thousands, and vertebrate animal fossils, the six thousands. Each of these groups was further subdivided on the basis of the phylum to which the fossilized animal or plant belonged. Thus a fossil elephant tooth was numbered 6751.

Varieties are shown by decimals. Thus quartz, classified with the silicates, is represented by the number 2901, while the varieties of quartz, rock crystal, amethyst, rose quartz, and smoky quartz, are shown by the numbers 2901.1, 2901.2, 2901.3 and 2901.4, respectively.

Duplicates of an individual are shown by a dash following the specimen number. A third duplicate of native copper would be given the native copper number 2004 followed by a hyphen and the number 3, thus, 2004-3.

This ends the system as far as the classification of an earth science collection is concerned but the plan may be expanded to include archeology, historical material or any other items at the will of the curator by assigning additional numbers to the list. It is believed that the system here proposed is perhaps more flexible than any now in use, inasmuch as it provides for additions to the collection, and assists in sorting, storage and exhibition or use of the material in an earth science collection.

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A Comparative Study of the Geographic Sites of Spencer and Bloomington, Indiana

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Spencer and Bloomington, Indiana, have many things in common. Each is a county seat of adjacent counties of approximately the same size. Both cities are located in the southern part of the state where settlement occurred first, and therefore their sites were selected at an early date. The site of Spencer was selected in 1815 and the site of Bloomington in 1816. Located only 18 miles apart they are in an area with humid continental climate having long summers and generally adequate precipitation, and both were originally surrounded by a broad-leaf, deciduous forest. As discovered later, they were located in an area without mineral fuels but in which stone would become an important commercial non-metallic mineral. Each city was originally settled by people who came from the same general area of eastern United States. During the first decades they served as trading centers for the early pioneers who were busy clearing the land and utilizing the virgin resources. During this time, the growth of the two villages was similar.

Of course there were and remain differences in their geographic sites. The contrast between their physical sites and the influence these have had on settlement and current problems stands out in bold relief. An understanding of the physical geographic site of any city is a prerequisite to geographic engineering. And it is interesting to note that in nearly every way the sites differ that the more favorable condition exists in Spencer, the smaller settlement.

Surface Configuration

Description. Spencer is located on a terrace which is part of a valley fill of the West Fork of the White River. The terrace at Spencer is approximately 30 feet above the average river level. Except for a few residences and commercial enterprises located on the valley slope to the north, the local relief is less than 20 feet.

In contrast, Bloomington sits astride a ridge which extends in a general east-west direction. This ridge which crests at Eleventh Street is a part of the water divide which separates the watersheds of the East and West Fork of the White River. Consequently the surface water which falls on the north slope of the ridge drains north by means of Griffy Creek and Butcher Creek to the Bean Blossom Creek and the West Fork of the White. Surface water falling on the south side of the ridge flows through several intermittent streams called branches into Clear Creek at the south edge of the city limits and hence into the East Fork of the White. Intermittent streams have cut back into the ridge from both sides creating a rolling topography. Although the city is small (there were 2,351 acres in the city in December, 1951), the topography is locally diversified.

Cultural Relationships. Spencer's rectangular street pattern is only broken in a few minor places, not by landforms but by the orientation of state highways. The thoroughfares are broad and adequate and appear

spacious for a town of its size. The only major traffic bottleneck is an old bridge which connects the trade territory south of the river with Spencer on the north.

The residential and other parts of the city may be monotonously level, but no one pays taxes for the construction of storm sewers, and storm water problems are few. Storm water drains to the river unhampered except by a railroad bed.

Although Bloomington has a roughly rectangular street pattern, it is superimposed on an uneven topography of ridges, ravines and rolling slopes. The areas enclosed by the major and secondary streets form squares and rectangles of varying sizes and arrangements. There are more short and dead-end streets. At present there are only two continuously oriented thoroughfares through the city, namely Walnut Street and Third Street, and the latter has two off-set jogs in it. Cultural features such as the University grounds, railroad properties and vacant land interrupt the otherwise rectangular street pattern.

Bloomington's streets appear and are in many places narrow and crowded. They have jogs, bends, and dips which handicap a smooth traffic flow and contribute to accidents. There are many traffic bottlenecks; blind vision spots; steep slopes which become icy in winter; and dips which flood during heavy downpours of rain.

Basement garages are a ubiquitous feature of the better residential areas and commonly associated with the better houses except those of ranch type construction. By orienting houses properly on sloping lots, basement garages are easily accessible and of rather low construction cost.

The rolling topography provides opportunities for building houses and commercial buildings to fit the slope. Some of the commercial buildings on the south side of the square have been constructed in response to the slope, but to date slope has had little influence on the architecture of the houses other than basement rooms and garages with ground level entrances.

Two outstanding examples of fitting house construction to sloping land can be found in Bloomington. One is a ranch-type house built on three levels to hug a southwest facing slope. The V-shape structure of the house fits a flat-iron shaped lot. The house hugs the topography so closely that a small earth dike had to be constructed up-slope from the house to divert the run-off from ponding in the apex of the V. The other house is located on the side of a south facing slope. It was constructed so deep into the side of the slope that the top of the house extends less than six feet above the up-slope side. The basement garage of this house is at street level. The house nearly flanks the sidewalk and one climbs a flight of stairs to enter it.

The rolling topography and steep grades influence rapid run-off (the engineering office gives the highest elevation at 820 feet and the lowest elevation in the southern part of the city as 720 feet) and thereby increasing the drainage problems. Only a very minor part of the city is served by underground storm sewers. Many blocks of streets are not flanked by any drainage ditch and many more have only a ditch on one side. Drainage areas along streets, whether gutters lined with cement or stone or open ditches, often become clogged with trash especially where culverts exist.

Clogged or too small culverts divert the water into and across the crushed stone and macadam streets washing away material and saturating the stone with water. Later with freezing and thawing and heavy traffic, "chug" holes develop and the streets deteriorate rapidly.

Also, the rolling topography plus a tight subsoil causes a high percentage of run-off. Heavy thunderstorms with large run-offs damage residential property and create disagreeable conditions. New houses constructed on too low a foundation, often with their longest dimension crosswise to the slope, dam the run-off until the water level rises sufficiently to run through the house. After this happens diversionary dikes and walls are made up-slope or power machinery is used to scoop out an amphitheatre-like area so the immediate upslope level is lower than the foundation.

The ridge site of Bloomington with the diverging down-grade slopes presents an expensive dilemma in constructing a sewage system. From the standpoint of gravity flow the divide stretching east-west along Eleventh Street cuts the city in two. Sewers draining downhill on the north side lead to a pumping station where it is necessary to put the material under pressure and hoist it to the top of the ridge so it can flow down the south side of the ridge to the city's sewage disposal plant two miles south and west of the city limits. Fortunately the drop from the highest point in the city to the sewage disposal plant is about 160 feet in a distance of few miles. The cost of pumping the sewage and repairing pressure mains is considerable and although residential expansion has taken place to the north, sewage main construction here has been limited. In a two-year period the primary pressure mains on the north slope had to be partially excavated and repaired twenty-three times. These mains were originally laid on bedrock.

Bedrock

Description. To date the underlying bedrock has not been a handicap to Spencer's growth. The bedrock lies approximately 100 feet beneath the surface of most of the city.

In contrast, Bloomington is located on a ridge, the core of which contains three types of limestone. The uneven and differential weathering of these limestones accounts for the diversity of the local topography. Large ravines with widening valley floors develop in the brittle and massive limestone called the Harrodsburg, while in the soft, massive Salem limestone gently undulating slopes develop. The greatest number of sinkholes are associated with the hard, dense, cherty St. Louis limestone, but these features may also appear in the other types.

Cultural Relationships. The possibility of striking bedrock is one of the primary construction hazards in Bloomington. Before or after buying a lot and prior to construction, the owner does or should make test borings to ascertain the depth of the underlying rock. Grids with mesh of various sizes are used with tests being made at the intersections. Some grid squares contain a yard and others four or nine square yards. The wider the test holes are spaced, the greater the danger of missing rock. Moreover, if construction of the test hole is stopped as soon as rock is reached,

there is no way of knowing whether one has reached the general surface of the underlying bedrock or only a residual boulder or the top of a rock point projecting up into the subsoil. Moreover, it is possible to take a rather large number of borings and by accident miss rather large lenses or several projecting points. It is also both exasperating and expensive to locate a place on your lot for a basement and, after constructing a nice basement, find that a ledge of rock separates the basement from the water and sewer mains.

In spite of careful test borings the risk of hitting bedrock, where not expected, is so great and so expensive that contracts are so drawn that the contractor is not financially responsible for additional costs. Today the estimated price for removal of a cubic yard of rock ranges from 15 to 25 dollars depending in part upon the nature of the limestone and its state of decay.

The discovery of bedrock after excavation begins sometimes influences a change in construction plans. A full basement may be reduced to half and in other cases plans for a basement are discarded. In the latter case the careful replanning of the house structure may be necessary. Unless new blueprints are drawn, makeshift changes reduce the utilitary, aesthetic and monetary value of the structure. Sometimes the site of the house on the lot must be changed thus disturbing the balance between the two. Other times the foundation of the house is raised creating a grading problem and causing the house to have a perched appearance. If the foundation is too high above the street level there is an additional problem and cost of constructing retaining walls, steep earth banks, or terraces, or a combination of these.

Retaining walls along one or more sides of city lots are a ubiquitous feature in Bloomington's landscape. Fortunately stone is locally available and often walls add beauty to the property. On the other hand, because many of the walls have not been constructed properly allowing for drainage, they are in a bad state of repair. Unless drainage is provided, heads of water build up behind. Good cement plus good construction are important, otherwise walls are moved by "heads of water" and alternating freezing and thawing. After heavy spring rains, walls may be seen bulging out of line or partially collapsed.

City administrators as well as individuals have construction headaches.

The underlying bedrock of Bloomington helps explain the city's limited sewer main system; the high cost of constructing and maintaining mains; and the dissatisfaction of some people on the sewer lines. Because of the high cost of excavating rock, in some places city sewers were laid as shallow as a foot and a half below the street surface. Consequently, locally there are mains at a higher level than the basements or sanitary systems they are expected to service. Some houses have small, enclosed catchment basins in their basements equipped with an electric pump. This pumps the sewage up to the city sewer main.

The city has an additional cost of laying sewer mains on a "cushion of gravel." All rock transmits shock in varying degrees and since blasting is common in Bloomington, sewers formerly laid on bedrock are often

broken and need repair. Today and in recent years city sewer contracts state that "an additional four inches of rock must be excavated and the space filled with crushed stone or gravel" which acts as a shock absorber. Here is an additional cost.

An additional physical handicap to sewer construction is the deep ravines on the side of the major ridge. Shallow installment of a sewer main on both sides of the ravine at a proper grade would cause the main to be exposed and even suspended at the bottom. Few sewer mains of this type have been constructed.

Sinkholes leading to cracks and caverns in the underlying bedrock have influenced several types of human response during the history of Bloomington. In the early days wells and springs were common. There were wells on the city square and basement springs helped preserve perishables. During water shortages in the city system, they provided water for household use and business purposes. Today most of the ground water in the mantle rock and the underground rock channels is foul smelling and contaminated. Some sinkholes are used as cesspools or septic tank outlets and some are partially occupied by outside toilets. If a sinkhole is used as an outlet, not so many feet of laterals need be constructed in the septic field.

With the bedrock so close to the surface, the city has a dual system of sanitary and storm sewers which means that two pipes are laid side by side. Such a system helps reduce the amount of vertical excavation that would otherwise be necessary, but increases the amount of horizontal.

The outcropping or shallow buried bedrock presents numerous problems to one who wishes to install poles, gas mains, water mains, or underground telephone lines or build driveways and streets. This element of the environment presents a constant headache of economic worries.

In contrast with Bloomington, the bedrock problems of Spencer are minor.

Mantle Rock

Description. In contrast with the friable, well-drained alluvial and glacio-fluvial sediments underlying Spencer, in Bloomington the mantle rock resulting from the weathering of limestone is primarily clay which is sticky or stiff and plastic when wet and compact and hard when dry. Originally the subsoil was covered with a few inches (about six or less) of friable loams. Today the subsoil is at the surface either because the top soil washed away during cultivation or because it was covered up by excavated subsoil and "fill dirt." These clayey subsoils vary in depth from nothing where the rock outcrops to 10 feet or more under natural conditions.

Cultural Relationships. The tight subsoil surface of Bloomington contributes to problems of storm water drainage, sewage disposal, droughty appearance of the residential areas, street construction, clouds of dust in dry periods, and reddish mud in wet periods.

In proportion to the amount of precipitation, drainage facilities must be larger because of the high per cent of run-off. At present the underground storm sewers and above ground drainage ditches are inadequate. Cost of construction and the maintenance of the existing artificial drain-

age is high. Street and drainage ditches have not been constructed to take complete advantage of the intermittent stream pattern on the sides of the ridge.

The light, compact, plastic subsoils with their low absorption qualities are a handicap to the construction and efficient operation of septic tank fields and create storm water problems. The clay trenches really tend to hold the water and retard its movement downward or horizontally. Wet or dry the clay is difficult to dig and the tile is seldom laid at the proper depth. Lacking a knowledge of septic field operation, some landowners remove part of the cover by grading or bury the fields with "fill" clay.

In addition to the clay, other physical conditions placing rigid limitations on the proper construction and functioning of septic fields are heavy thunderstorms, uneven topography and soil erosion. Alternate freezing and thawing followed by heavy thunderstorms remove much top earth. After heavy rains disagreeable odors are common. Many fields are so flooded and water-soaked after an inch of rain that two common sights prevail. One is the man with his truck to empty the septic tank until the fields can drain again and the other is "weeping"; wet spots indicating "septic tank trouble." In winter a blanket of snow following a thunderstorm quickly has its tell-tale brown stains and melted spots indicating where the warm water from fields is seeping or running to the surface, a process locally called "weeping." Unfortunately the speed of seeping is accelerated during heavy rains and the material is carried down slope to the neighbors. Basement wet weather "springs" are common after these rains, and odor as well as dyes have substantiated that a neighbor's septic tank is the source of some basement water flows.

Contrast this Bloomington situation with Martinsville or Spencer or many other Indiana towns and cities where septic tank fields may be constructed in friable silts, sands, loams, and gravels.

Nice sod lawns or gardens are rare. The greatest natural limitation to good lawns and gardens is the dryness of the earth. Water tables fall rapidly or are absent in many yards because of the underlying limestone or the overlying blanket of excavated clay. Soon after an inch of rain in summer, the earth cracks open. It is doubtful if 20 per cent of the falling rain enters the ground in many yards. Where less than 10 inches of the 44 inch annual rainfall enters the ground, desert-like conditions prevail unless water is added.

Both artificially added water and rain evaporate quickly, run off or through. The surface material is low in vegetable matter or humus, and long slopes and terraces contribute to lowering the water table. Water is comparatively expensive in Bloomington and many water their yards lightly or not at all. Some who can afford large water bills and let their sprinklers run all night are not aware that much of the water runs through mantle rock fissures down to the fractured limestone below and into the great network of cracks and caverns in the bedrocks. Fortunately the tree roots enter these cracks and rock channels and are not so subject to the droughty conditions.

Numerous freezes and thaws also damage good lawn grasses especially if the grass has been weakened by a dry summer and fall.

In part because of the uneven relief, the clayey mantle rock and the underlying bedrock, street construction costs are high. Miles of city streets both graded and ungraded are either of earth or crushed stone. Clouds of dust bedevil the housewives during the dry periods. In some places applications of oil help hold down the dust but contribute to the development of "chug holes" and "washboard" surfaces. Most new blocks present fill and rock removal problems.

In contrast with Bloomington, in Spencer ditches can be constructed easily by hand and machine. In this town three separate parallel sanitary systems lead to the river. Since no one main must carry the complete load, smaller pipes are used. Buildings costs of city facilities are lower. Spencer's growth is encouraged by its good mantle rock and soil.

Waterbodies

One of the biggest contrasts between the sites of Spencer and Bloomington is the fact that the former is located on the edge of one of the largest rivers in the state whereas Bloomington is located far from a large river or natural lake and is on topography, bedrock and mantle rock, which excludes the possibility of constructing a lake nearby that would provide the necessary water.

After a history of reoccuring water shortages dating back to the 1890's, the city of Bloomington completed construction of a 1,600-acre reservoir lake in 1953. When full, the reservoir holds 5.5 billion gallons of water. But this lake had to be built about 10 miles northeast of the city limits and partially in adjacent Brown County. The water from the new Bean Blossom Lake still must flow through the old Bean Blossom creek channel to reach Griffey Lake reservoir, the former primary source of Bloomington's water.

An abundant water supply has brought a chain of reactions all of which cannot be considered in this paper. Blueprints have been drawn for an expansion in the water system. On October 16, 1953, Mayor Emmett Kelly stated that "engineers of Consoer-Townsend began sounding water main routes for stone today, in order to find the best routes for the lines and to get a more accurate engineering cost estimate." On October 28, 1953, the City Council passed an ordinance "hiking water rates from a minimum of $1.50 a month to $2.25."

A sewage disposal plant built in 1934 is now too small and plans have been drawn for enlarging both the disposal plant and the sewer mains.

The water and sewer service in Bloomington have cost the people millions of dollars and the total costs continue to rise.

In contrast Spencer takes its water from wells constructed in the Valley fill and empties its untreated sewage into the river. Water and sewer costs remain low.

Favorable Site for Pioneer Village

Viewed in retrospect many people raise the question, "Why did the original settlers select such an unfavorable physical site for Bloomington?"

When occupied in 1816 the physical site had many characteristics favoring its selection and the people of that day did not visualize the technology and needs of our times.

One hundred and thirty-five years ago a well-drained site was an important criteria in selecting a spot for village development. At that time the millions of acres of swamp land in Ohio, Indiana and Illinois had not been drained. Water tables were high and mud was a handicap to those who walked, rode or drove cattle or horse-drawn vehicles. A high, well-drained area had less mud and the people believed that disease was not so common there. Much pioneer illness and many deaths were attributed to disease such as malaria and ague resulting from swamps.

Other favorable factors were the timber, stone and water. The ridge was wooded and the rolling nature of the land offered many good residential sites. Building stone for foundations, steps, wells and cisterns was available and easily tooled. Springs of pure water and the other natural water courses provided an adequate water supply for both man and animals. When these became inadequate, wells and cisterns were constructed. At that time the water table was high and the ground water uncontaminated. Meadows furnished grazing grounds for animals. The village of Bloomington did not suffer from water shortages and the first city water works consisting of a small lake and pump was not constructed until 1894.

Unfavorable Site for City in Twentieth Century

As the population in Bloomington grew and the pioneer village changed into a modern, Twentieth Century city, limitations in the physical site became more and more real, apparent and costly. However, in spite of these limitations, the city continues to grow because of other favorable geographic factors which cannot be treated within the limits of this paper but will be presented later. Bloomington's population in 1950 was 28,163 and Spencer's 2,386.

Indiana Grain and the Illinois-Mississippi Waterways

J. Edwin Becht, Indiana University

Introduction

Important geographic changes in the marketing pattern of Indiana corn, wheat, soybeans and oats are being effected chiefly by three factors: 1) the development of modern barge traffic on the Illinois, Mississippi, Ohio, Cumberland and Tennessee Rivers; 2) an increasing dependence on truck transportation; and, 3) Indiana's gross income tax on intra-state grain transactions. On one hand, Indiana's gross income tax and the increasing use of trucks are the most direct and noticeable causes effecting current geonomic changes in the marketing of Indiana's grain. On the other hand, the fact that the development of grain traffic on distant waterways is even indirectly affecting the movement of Indiana grain provides an excellent illustration of the complex nature of grain marketing in the United States today.

Transportation and storage are highly important in the marketing of grain. Raw grain is a relatively cheap, bulky, slow-to-spoil commodity requiring storage. For these reasons shippers find it advantageous to move grain by barge. The initial movement of grain from Indiana farms is almost entirely by truck. Trucks are also the prime mover of grain to terminal elevators and processing plants located less than 35 miles from producing farms or local elevators. In addition, trucks are becoming of greater importance in the hauling of grain for distances up to several hundred miles through farmer and local elevator sales to itinerant truckers and in conjunction with barge operators. Rural elevators ship chiefly by rail to processing plants and terminal elevators; this is particularly true of grain moving to eastern markets, to Atlantic ports for export, or to processors for in-transit milling.

A highly generalized pattern of the movement of Indiana's grain to market appears as follows (figure 1):

1. By rail to eastern markets for processing or distribution.
2. By truck and rail to Indianapolis for processing or distribution to the East.
3. By truck and/or rail to Indiana processing plants.
4. By truck and rail to Toledo, Ohio, for processing or reshipment to the East.
5. By truck and rail to Chicago for processing or reshipment to the East.
6. By truck to riparian elevators at Morris, Illinois.
7. By rail to Decatur, Bloomington and Peoria, Illinois.
8. By truck to Danville, Illinois, for processing.
9. By truck to Louisville, Kentucky, and Cincinnati, Ohio, for processing or distribution throughout the South and Southeast.

The combined market value of Indiana's 1952 crop of corn, wheat, soybeans and oats exceeded $700,000,000 and represented an important share of the State's total income for that year. Any changes in the market

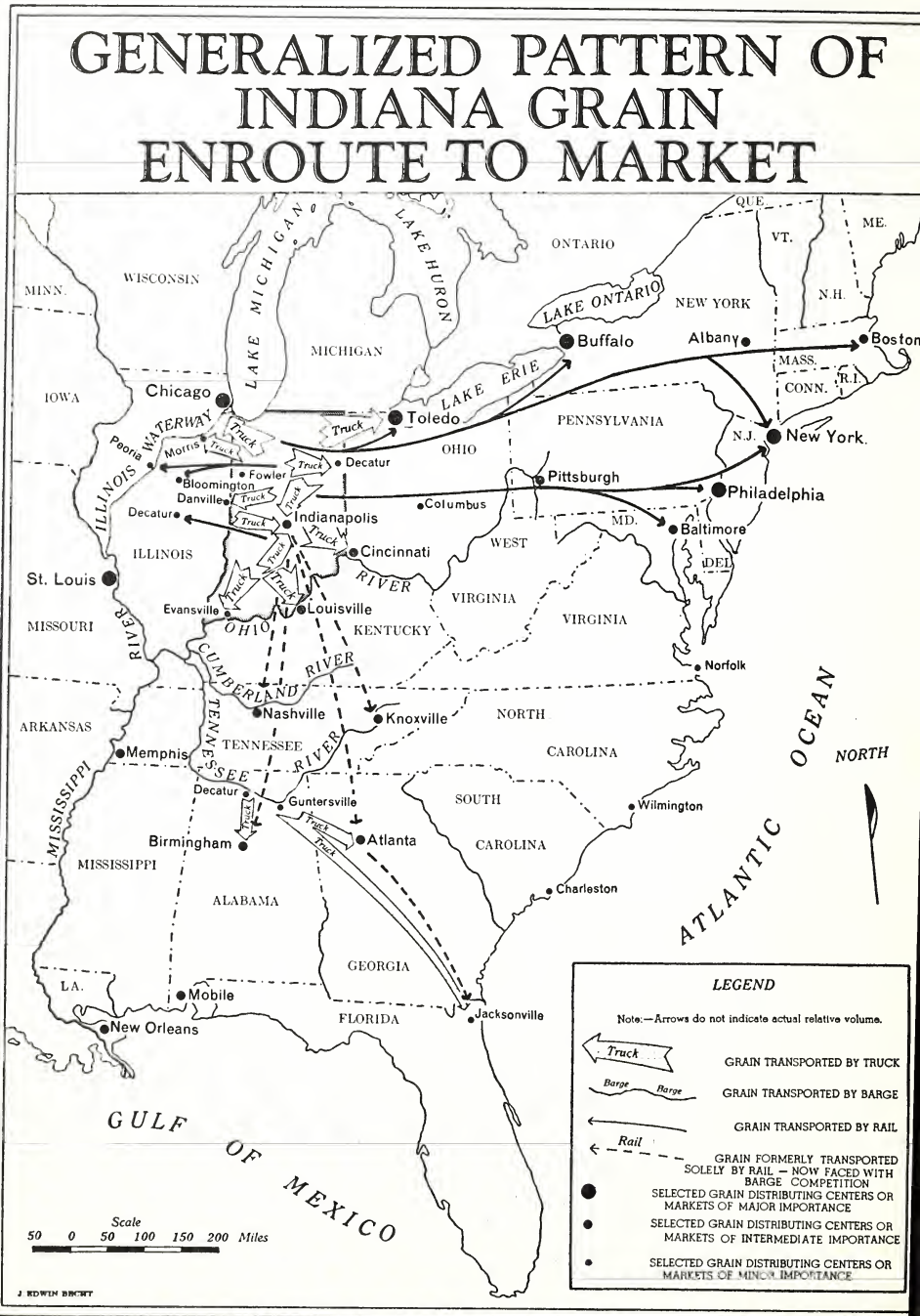
GENERALIZED PATTERN OF INDIANA GRAIN ENROUTE TO MARKET
WISCONSIN
MINN.
IOWA
MICHIGAN
ONTARIO
QUE.
VT.
ME.
N.H.
NEW YORK
MASS.
R.I.
CONN.
N.J.
PENNSYLVANIA
OHIO
WEST VIRGINIA
VIRGINIA
MD.
DEL.
KENTUCKY
TENNESSEE
MISSOURI
ILLINOIS
ARKANSAS
MISSISSIPPI
ALABAMA
GEORGIA
FLORIDA
LA.
NORTH CAROLINA
SOUTH CAROLINA
LAKE MICHIGAN
LAKE HURON
LAKE ERIE
LAKE ONTARIO
OHIO RIVER
CUMBERLAND RIVER
TENNESSEE RIVER
MISSISSIPPI RIVER
ILLINOIS WATERWAY
ATLANTIC OCEAN
GULF OF MEXICO
Chicago
Toledo
Buffalo
Albany
Boston
New York
Philadelphia
Baltimore
Pittsburgh
Columbus
Indianapolis
Cincinnati
Louisville
Evansville
St. Louis
Nashville
Knoxville
Memphis
Decatur
Guntersville
Atlanta
Birmingham
Mobile
New Orleans
Jacksonville
Charleston
Wilmington
Norfolk
Peoria
Morris
Bloomington
Danville
Fowler
Decatur
Truck
Barge
Rail
Scale
50 0 50 100 150 200 Miles
J. EDWIN BECHT
LEGEND
Note:—Arrows do not indicate actual relative volume.
GRAIN TRANSPORTED BY TRUCK
GRAIN TRANSPORTED BY BARGE
GRAIN TRANSPORTED BY RAIL
GRAIN FORMERLY TRANSPORTED SOLELY BY RAIL — NOW FACED WITH BARGE COMPETITION
SELECTED GRAIN DISTRIBUTING CENTERS OR MARKETS OF MAJOR IMPORTANCE
SELECTED GRAIN DISTRIBUTING CENTERS OR MARKETS OF INTERMEDIATE IMPORTANCE
SELECTED GRAIN DISTRIBUTING CENTERS OR MARKETS OF MINOR IMPORTANCE

Figure 1

potential for that grain is important to every taxpayer in the state. To handle this trade a complex commercial structure has developed within the state and includes farmers, local (or rural) elevators, riparian elevators, large and small grain exchanges, terminal elevators, processors, truck-load and carlot dealers and commission men.

Development of Modern Barge Traffic

For the past century Indiana grain producers, located on the eastern fringe of the great mid-west grain producing region, have enjoyed the advantages of relatively low basic rail rates to the east and southeast and, in addition, a relatively short-haul to Chicago—the world's largest grain market. Now, because of low competitive barge-load rates on grain to Chicago and to the Southeastern markets, shippers of Indiana grain find that their counterparts in Illinois and adjacent areas of Minnesota, Iowa and Missouri are successfully competing for much of Indiana's share of those markets. Another change in the marketing pattern of Indiana's grain has taken place in that considerable quantities of grain are being trucked to Illinois and Ohio River elevators—i.e., Morris, Illinois and Evansville, Indiana respectively.

The development of modern barge traffic on the Illinois Waterway has resulted in a new freight rate pattern for Illinois and Indiana corn, wheat, soybeans and oats moving to the Chicago market. Now, Illinois farmers located as far as 250 to 300 miles from Chicago are able to compete with Indiana producers located only 40 to 50 miles from that market. The impact of this new truck-barge, truck and truck-rail rate pattern has been far-reaching and complex, affecting nearly all grain farmers, shippers and processors in those two states.

Since the opening of the Illinois Waterway in 1935 grain shipments on it have reached an annual total exceeding 60,000,000 bushels. More than three-fourths of this total moves upstream and constitutes about 35 percent of all grain reaching Chicago. The balance moves downstream to the important grain centers of St. Louis and New Orleans and to numerous lesser market and distributing points such as Decatur and Guntersville, Alabama and Nashville, Tennessee.

Direct results of low cost water rates into Chicago on the grain marketing pattern of Indiana are: 1) a reduction in the size of the area of northwestern Indiana able to compete with the region of Illinois having newly established, uniformly low rates to the Chicago market; and 2) the widespread use of trucks in conjunction with barge operations. Indirect results are: 1) areal shifts to livestock and other types of farming from cash grain; 2) a decline in the relative importance of local grain markets; and, 3) shifts in the direction of grain moving from areas which formerly shipped to Chicago but which now lie outside producing areas enjoying sufficiently low rates to compete for that market. To date, major Indiana grain exchanges and farmers have not felt this loss of trade keenly because: 1) only the northwestern part of Indiana has been, and is, oriented toward the Chicago market (figure 1); 2) demand has remained at a high level; and 3) Federal price supports moderate the effects of differences in freight rates on grain. However, the effects of these differences in

rates would become highly important in the future if demand should slacken, or if price supports are dropped.

Even more spectacular has been the success that water carriers have made possible for shippers moving grain from Illinois (and points even further to the west and north as well) into the southeastern states. Grain can be shipped from all Illinois Waterway elevators south of the big bend in the Illinois River to major markets in the Southeast at much lower costs than it can be railed from Indianapolis to those same markets. These savings range all the way from 69 cents per hundredweight for such points on the Tennessee River as Guntersville and Decatur, Alabama to 14 cents per hundredweight on grain destined for Jacksonville, Florida—some 440 miles by truck southeast of Guntersville (Table I).

Just how serious the loss of a large share of the southeastern markets has been to Indiana grain dealers is difficult to assess. Records are unavailable that show the amounts formerly shipped from Indiana to those points.[1] However, a record of the annual tonnages of corn, wheat, and oats moving up the Tennessee River indicates that the amounts involved are substantial and of growing importance (Table II). These tonnages have increased from 12 short tons in 1938 to more than an estimated 200,000 short tons in 1953. Approximately two-thirds of this volume is corn and nearly all of the balance is wheat. That this new traffic is hurting the Indiana grain trade is further attested by the fact that a number of southern railroads have filed counter-complaints with the Interstate Commerce Commission contending that present barge line rates and charges are not sufficient to cover the cost of barge operations.[2] Naturally, the future of this traffic hinges upon the outcome of these complaints.

TABLE I

Comparison of Rail Rates From Indianapolis, Indiana to Selected Southeastern Markets With Barge, or Truck-Barge, Rates From Certain Illinois River Points To Those Same Markets*

To	By Rail From Indianapolis	By Barge and Truck *From* Illinois River Points South of the Big Bend	Differences In Favor of Barge and Truck
Atlanta, Georgia	$ .89	$ .47	$ .42
Birmingham, Alabama ..	.86	.35	.51
Guntersville, Alabama ...	.86	.17	.69
Jacksonville, Florida	1.19	1.05	.14
Knoxville, Tennessee	.73	.22	.51
Louisville, Kentucky	.42	.13	.29
Nashville, Tennessee	.65	.19	.46

* Rates in cents per cwt. Rail rates are C/L-I. C. C. A 946 and water rates are B/L-I. C. C. No. 16 and I. C. C. No. 104. Truck data are based upon a cost figure of 1 cent per cwt. for each five miles.

1. Probably of greater significance to Indiana grain dealers has been the development of grain movement by truck to Louisville, Kentucky and Cincinnati, Ohio for transhipment to southeastern markets.

2. I. C. C. docket Nos. 30744 and 30787.

TABLE II

Inbound Grain Traffic On The Tennessee River*

Year	Corn	Wheat	Oats	Total
1938	12	0	0	12
1939	137	5,473	0	5,610
1940	19,011	19,340	2,809	41,160
1941	42,022	69,806	1,216	113,044
1942	31,775	57,188	2,398	91,361
1943	53,743	59,464	4,856	118,063
1944	.....	.....	.....	.....
1945	60,079	51,684	11,098	122,861
1946	25,378	42,623	10,300	78,301
1947	40,445	35,316	7,002	82,763
1948	33,894	25,539	3,321	62,754
1949	64,468	31,774	8,857	105,099
1950	102,638	41,933	14,146	158,717
1951	68,288	56,798	13,701	138,787
1952	135,015	40,837	24,007	199,859

* Source: U. S. Army Engineer; Data in Short Tons.

Increased Dependence on Truck Transportation

The increased use of trucks for hauling Indiana grain, other than from farm to local elevators or nearby processing plants, is relatively new and has made possible the moving of grain by barge. Since 1947 there has been a series of increases in railroad freight rates on grain. Each increase has resulted in a greater spread between truck and truck-barge rates on the one hand and rail rates on the other. This wider spread in rates set in motion a whole series of adjustments, one of which was to greatly increase the number and extent of areas in which trucks can compete with rail. Still another reason for the rapid growth in the use of trucks to haul grain is the recurrent box-car shortage at harvest-time. Grain-shippers, hard pressed to find storage for their grain, are forced to turn to trucks to aid in moving their commodity to terminal elevators. Trucks, thus placed into operation, remain available throughout most of the year.

Trucks have very nearly replaced rail in moving grain from large sections of Indiana. Trucks hauling from almost the entire southeastern part of the state to Louisville, Kentucky and Cincinnati, Ohio have practically replaced the railing of grain from Indiana points to those markets. Similarly, trucks have a near monopoly on the grain trade from the northwestern corner of the state to the Chicago market and to riparian elevators at Morris, Illinois. Trucks also dominate in the movement of grain from the southwestern part of the state to Evansville; and are being used more and more to move grain from the northeastern part of the state to Toledo, Ohio.

Effects of Indiana's Gross Income Tax on Intra-State Grain Transactions

One outstanding result of Indiana's gross income tax on the marketing pattern of grain grown in the state has been the enlargement of producing sections having their most favorable markets outside of Indiana. For example, the radii of the areas that are in a position, rate-wise, to truck grain to riparian elevators at Morris, Illinois, or to Ohio River houses in Evansville rather than to major Indiana markets, are increased from 5 to 10 miles—the equivalent of more than a large county in each case. Similarly, the radii of areas normally trucking grain to the important markets of Chicago, Toledo, Cincinnati, and Louisville have been increased from 5 to 10 miles.

These increases have resulted from the fact that the state gross income tax on intrastate transactions restrict to a degree the operation of the state's grain elevators, carlot dealers, commission men and grain exchanges, most of whom operate on margins of less than 5%. As each grain transaction is taxed one-fourth of one percent of its gross value, even if a loss is incurred, the average tax on a given bushel of grain, after passing through 3 to 4 hands before reaching the final processor, amounts to approximately 1% of its market value. This is usually more than one-fifth of the expectable margin of profit for most commission transactions. For example, if the market price of corn per bushel is $1.80, wheat $2.50, soybeans $2.75 and oats $.90 this cumulative tax on 1% amounts to 1.8 cents, 2.5 cents, 2.7 cents and .9 cents per bushel respectively. These amounts represent more than the price ranges of the major markets on many days and considerably reduce the competitive position of Indiana grain dealers. In brief, the tax encourages the moving of all grain destined to be marketed outside of the state with the least possible number of intra-state transactions; and, as has been pointed out, out-of-state markets include riparian elevators.

Conclusions

The widespread use of barges and trucks are relatively new and their final effects on the marketing of Indiana grain have not yet developed. Barring major decreases in rail freight rates, or rulings adverse to barge operators by the Interstate Commerce Commission, the present trends will continue and the railing of Indiana grain to Chicago and to the Southeastern markets will continue to decline in importance. And, as long as Indiana applies a gross income tax to all intrastate grain transactions, Indiana dealers will tend to deal more and more directly with out-of-state markets and sources of grain. The tax encourages the railing of grain to eastern markets and ports and favors the trucking of grain to Chicago, Toledo, Louisville, Evansville, Danville (Illinois) and to Morris on the Illinois Waterway rather than to the Indiana markets.

Martinsville, Indiana, a Satellite Town

WILLIAM E. THOMSON, Indiana University

Martinsville, the county seat of Morgan County, lies 35 miles south, southwest of Indianapolis just east of the White River. It has become the cultural, financial, political and industrial center of the county and its service area includes most of the county.

Martinsville is, however, included in the area serviced by Indianapolis. This fact is most evident by the flow of many people into Indianapolis. There is also a movement in and out of shoppers and of people seeking recreation or professional services. Conversely there is a movement of goods from Indianapolis to Martinsville, including newspapers, certain perishable goods and representatives of business agencies which render service.

Before pointing out the essential features which help determine Martinsville's role as a satellite, it is wise to examine the city geographically, for these facts more than anything else help to explain why Martinsville is a satellite of Indianapolis.

Martinsville has a fairly extensive service area. Certain geographical features have been essential in its growth. The relatively fertile agricultural area surrounding the city is situated partly on an extensive flood plain which has been influenced by past glaciation and later by flooding of the White River. The wide diversification in agriculture of the area is due partly to the fact that it has diverse soils: unglaciated, glaciated, and alluvium. Intensive farming practices were encouraged by the fertile soils and by the development of advanced farm machinery and large consumer markets in Indianapolis and other nearby centers.

The abundance of local natural resources of forests, fresh and mineral waters, and building clay, have further enhanced the growth of Martinsville. The forests played a major role in the early growth of the city when furniture factories, cooperages, and sawmills were important. With the drastic depletion of local supplies, the woodworking industries declined sharply but they still remain relatively important with the aid of importation of lumber. Woodworking factories still employ a major group of the employed people, both men and women.

Mineral water found in geological strata deep beneath the city formed the basis of a health resort industry. Although the health resorts which commenced in the 1880's reached a peak in popularity about 1915, four resorts still operate at near capacity.

An abundant supply of pure fresh water is found in fluvioglacial sands and gravels beneath and near the city. It provides adequately for the needs of domestic and industrial utilizers. It was the basis for the development at Martinsville of the largest goldfish hatchery in America, The Grassyfork Goldfish Hatcheries.

Large deposits of clay located just north of the city limits have been important in the manufacture of brick and tile. The relatively short distance of Martinsville from the coal fields of southwest Indiana and its

position on the railroad, facilitated the importation of fuel. Nearby growing urban centers have provided ready markets for brick and tile.

The White River Valley, for a long time during glaciation, carried off the runoff of much melting ice—was a great glacial spillway. It provides a natural passageway for roads and railroads leading north through Martinsville to Indianapolis. State Roads 37 and 67 extend from Indianapolis south through Martinsville to Vincennes, Bloomington, Bedford and Louisville, Kentucky. The Pennsylvania Railroad connects the coal fields of southwest Indiana and the markets of Indianapolis via Martinsville. The facilities offer quick and efficient transportation of local manufactured goods and agricultural produce.

Approximately midway between Indianapolis and Bloomington, Martinsville's relative location has advantages and disadvantages. Some advantages are: Its residents can reach Indianapolis by automobile, trucks, or bus in less than an hour over all weather roads. Many work there, while others shop or market local products including livestock, farm produce, and bricks. Others use Indianapolis' excellent railroad and airplane facilities, seek entertainment, or attend one of the institutions of higher education. Consequently in this era of quick transportation, both Indianapolis, and in a smaller way, Bloomington, are "crowding" Martinsville, and the "trade shadow" influence of these two is becoming increasingly important. For example, advertisements of employment possibilities in both larger cities appear in the Martinsville paper, and more people each year commute to these two nearby cities to work.

Disadvantages of Martinsville's location include: The loss of young men from the city to industries of Indianapolis and Bloomington has recently become pronounced with the result that local industries have resorted increasingly to the employment of women. The men seek the higher wages offered in the larger centers while still enjoying a lower cost of living by residing in Martinsville. Many residents and local rural people travel to the larger cities for shopping or recreation and thus the local retail district suffers. The trade area of Martinsville is limited in extent to the north and to the south by the proximity and influence of Indianapolis and Bloomington respectively.

Martinsville's advantages include: 1) Choice building sites at relatively low cost. 2) Relatively low cost of living. 3) Fairly satisfactory city services. 4) A suitable labor supply, mostly female, which is available for light industry. 5) The fact that Martinsville is the political center of Morgan County is an asset of value. 6) Pleasant environmental conditions influence the settlement of many people in the city.

This short geographical survey of Martinsville reveals a close relationship with the economic and social functions of Indianapolis. Indeed Martinsville is a satellite of Indianapolis.

All the essential features of a satellite town are present in Martinsville. It is far enough away from the central city to have its own self-contained public utilities and local transportation systems. The majority of the employed inhabitants work in Martinsville. However, perhaps one-fourth work in Indianapolis and a smaller number in Bloomington. These facts are of major significance in the development of a satellite town.

Another important consideration is industry. In Martinsville, industry largely dependent on local natural resources, is sufficient to provide for a solvent local government. Recreational land use is also large enough to satisfy most of the inhabitants.

The city is linked closely by road to Indianapolis and Bloomington. The Pennsylvania Railroad links the city to Indianapolis to the north and to the coal fields a short distance southwest.

People realize that satellite towns are growing near most major metropolitan centers. Industrialists themselves are showing recognition of the frequent desirability of movement of plants from the large center to satellite towns.

Several plants in Indianapolis are moving or expanding by building in smaller cities to escape high real estate taxes and crowded conditions while remaining close to markets and raw materials and near a labor supply. For example the Basca Manufacturing Company has located in Martinsville. Moreover, Alsco has its main assembly plant there.

This satellite town not only is benefitted by the movement of industry and people from the large urban center but also helps the large center. It offers a practical solution for the expanding urban growth of Indianapolis. For with a movement of people to a smaller nearby city, the larger urban center is relieved from spreading beyond present economic bounds.

On the basis of the above short survey and personal observation made during 1953 of Martinsville and its environs, it appears that this city should grow. In the last three decades it has expanded from 4,962 residents to over 6,500 inhabitants. It should become more and more of a home for commuting workers because of lower costs of living, of more available building sites at moderate cost, good shopping districts and proximity to the nearby Indianapolis. Several subsidiary and branch industries have located in the city and with the trend for industry of Indianapolis to seek new building sites in nearby small cities, Martinsville doubtless will continue to benefit from this outward movement. Thus the town will continue to play an important part as a satellite for Indianapolis and the role will benefit both centers.

A new element of cooperation between the two cities is desirable, so as to carry out a regional plan of urban development. Desirable also is a great deal more thought by the town council in regards to the financial status of their smaller urban center in order to extend desirable urban services and other facilities. Martinsville has a strategic site and is blessed with good local natural resources, and by importance as a major satellite. Geographical factors will continue to play an important role in its progress.

Ground Water Conditions of the Unglaciated Area in the Southern Part of Indiana

T. M. KINGSBURY, Indiana Department of Conservation

During the past few years there have been phenomena which have focused attention on our water resources as never before. Only a few years ago a new phrase was created to describe a new condition in the mid-western states. This phrase was "the dust bowl." More recently the nation was shocked by the news of a water shortage in the great city of New York. In the past summer widespread droughts have brought hardships and serious economic losses in many states.

While some of the reports of these circumstances have been exaggerated and sensational, the fact remains that water in sufficient amounts to meet present domestic and industrial needs is a serious problem. In our own state this problem is becoming of more and more concern. While there are areas of ground water shortage in various parts of the state, southern Indiana is usually hardest hit. More particularly this is true of the unglaciated area and the hilly region along and for some miles back from the Ohio River.

The seriousness of the situation in a large portion of this general area is much greater than most people realize. During the summer and fall seasons just past, failures of water supplies were general. Wells went dry. The same is true of cisterns. Farm ponds, of which there are a great many in that area to furnish a supply of water for livestock, became stagnant pools. In some localities municipal supplies became so exhausted that warnings were issued to conserve the water by limiting its use to most essential purposes. The hauling of water to rural areas in tanks mounted on trucks became necessary over the entire area along the river and as far north as Brownstown and Bedford. The Evansville station of the U. S. Weather Bureau recorded only 6.85 inches of rainfall from the beginning of June through October. The deficiency from normal for this 5-month period was 9.28 inches. This period was marked by high temperatures which increased evaporation losses. The net result caused crop losses, especially to pasture land, and increased fire hazards in large areas of timber lands.

Conditions approaching in varying degrees those which occurred during the past summer are the rule rather than the exception in southern Indiana. Yet that part of the state normally receives a greater amount of precipitation than other parts. Why then are water shortages more common and the problems of obtaining an adequate supply more complex there, than in most of the northern three-fourths of the state?

Precipitation is the only source of our water supply. It is of first importance in considering water problems. This is especially true in southern Indiana. That part of the state normally receives more than 40 inches annually whereas the state as a whole receives slightly less than that amount. In parts of southern Indiana the normal yearly precipitation amounts to more than 45 inches. This is more than 10 inches in excess

of the normal received in portions of the northern part of the state. The area around Marengo receives more precipitation than any other part of the state. From a standpoint of water supply the annual precipitation is divided into three periods: (1) The storage period which in the latitude of southern Indiana is from December to May, inclusive, (2) The growing period, from June through August, and (3) The replenishing period from September through November. There is little runoff except in the storage period and a deficiency in precipitation at this time is rarely made up during the other periods. During the growing period more than the usual amount of rainfall is required by plant growth. Ground water storage is at a seasonal low at the end of this period. Precipitation during the replenishing period goes into ground storage.

The geology of the area under discussion is the second most important factor. The region as a whole is comparatively rugged. To the east and in the area commonly known as the Knobs, the topography is marked by deep, steep-sided valleys, with limited upland areas and broad flat valleys only along the larger streams. The Mississippian limestone regions to the west are characterized by a more rolling topography. It is a region of caves, sinkholes and uncertain underground drainage. Farther west are alternate strata of limestones, shales and sandstones. The topography is more like that to the east. It is rugged with deeply cut stream beds and excessive surface erosion.

This type of topography and rock formations are related to water resources in a number of ways: (1) In practically all of this unglaciated area there is an absence of loose material over-laying the native rock, and storage areas for ground water are therefore extremely limited. This condition is, of course, reversed in much of the glaciated areas to the north. (2) In areas of rugged topography, where hillsides are steep and valleys are narrow, the surface runoff is rapid. Rainfall is not retained long enough to permit much penetration below the surface. Also, in the central limestone area in southern Indiana much of the rainfall is lost through sink holes and subsurface drainage which form an intricate system of subterranean streams. (3) The character of the bed rock formations in a large portion of the general area are not well suited to holding or transmitting water. There are large areas of relative impervious shale. Some of the sandstones are so cemented that they are also impervious. Shallow wells yield water slowly and become practically dry in drought periods. Deep drilling does not solve the problem except in isolated cases. Some deep wells produce only 2 to 5 g.p.m., some may produce mineralized water.

The solution to the water problem appears to be to retain precipitation when and where it falls in well constructed ponds and reservoirs. The experience of the past summer should be a lesson. The reservoirs should be larger in size and greater in number than those which exist at present. The impervious character of the bed rock, the thin layer of soil, predominately clay, which overlies it, and the typical rugged topography of the surface, while unfavorable for the collection and retention of rainfall, are, in many areas, most favorable for the impounding of surface water supplies.

HISTORY OF SCIENCE

Chairman: C. L. Porter, Purdue University

M. S. Markle, Earlham College, was elected chairman for 1954

ABSTRACTS

Air-conditioned light rooms for growing plants. Raymond E. Girton, Purdue University.—As early as 1924 a completely air-conditioned light room (11 x 11 ft.) was constructed and in use at the Boyce Thompson Institute for Plant Research in Yonkers, New York. Incandescent lamps provided 400 f.c. light intensities at plant height. Temperature control was within 1 degree and humidity control within 2%. A much smaller (2 x 5 x 5 ft. high) and much less expensive light chamber installation was described by A. R. Davis and D. R. Hoagland in 1928. Here again, temperature control within 1 degree (C) was claimed but a much less rigid control of humidity was obtained. Light was supplied laterally by incandescent lamps at an intensity upon the plants of 2610 foot candles. Accurately predictable growth data could be obtained with wheat plants growing under these conditions.

More recently constructed light rooms have utilized fluorescent lamps as a more satisfactory illumination source. Fluorescent lamps produce an illumination quality more nearly comparable to sunlight and are much more efficient light sources than incandescent lamps. For these reasons the new light-room installations at Purdue University employ fluorescent lighting. The room in Peirce Conservatory measures 9 x 10 x 8 ft. high and is illuminated by fifty-eight 96-inch fluorescent lamps suspended above a triple-glass Thermopane screen. Intensities at plant height are of the order of 1,000 f.c. Temperature controls permit a temperature range of 50-85° F. ± 3° F. The humidity range is 30-85% (and higher) ± 5%. The four light rooms of the new Plant and Soils Laboratory Building are similarly illuminated with a maximum light intensity of about 2,000 f.c. Temperature control is within 2 degrees and over a range of 50-80° F. Humidities may be varied over a wide range with a control within limits of about 5%. Satisfactory plant growth has been obtained under fluorescent lighting in both of the Purdue buildings mentioned.

The history of science at DePauw University. Will E. Edington, DePauw University.—The history of science at DePauw University is probably very similar to that of other Indiana colleges founded before 1850: a struggle for the recognition of science as of equal value to the classics in education. Early instructors were ministers trained in the classics and sincere in their beliefs that an educated man must know Latin and Greek. Also the proper teaching of science requires appartus and laboratories, which cost considerable money for both equipment and laboratory space. Enrollments were small and instructors generally taught several subjects. However, by 1848, DePauw was offering a two-year Scientific Course and German was taught. The first Medical School to

be associated with an Indiana college was set up in 1849 and ran until 1852. By 1853 the Scientific Course was extended to three years, and in 1858 a full four-years course was given leading to the B.S. degree, and students could substitute French or German for Latin. By 1869 a chemical laboratory for student use had been set up and one term of laboratory work required. Also the privilege of "elective courses" was permitted to a limited extent. In 1875 the possibility of specialization in mathematics was provided for in "extra-collegiate hours." By 1890 science was fully recognized and taught on a laboratory basis, and outstanding specialists were employed as instructors.

Among the great names associated with the early history of science at DePauw are Charles G. Downey, William C. Larrabee, Cyrus Nutt, Joseph Tingley, John W. Locke, Patterson McNutt, J. P. D. John, J. B. DeMotte, C. A. Waldo, J. P. Naylor, P. S. Baker, O. P. Jenkins, L. M. Underwood, W. W. Norman, W. V. Brown, Mel T. Cook and H. J. Banker. During the present century under the guidance of William M. Blanchard, T. G. Yuncker, B. H. Grave, O. H. Smith, Ernest Rice Smith, C. P. Hickman, F. D. Brooks and Will E. Edington, DePauw University has become one of the leading institutions in the United States in preparing and sending students in science to the graduate schools, where several hundreds of its graduates have earned Ph.D.'s in science and are now actively engaged in scientific work.

History of the Arthur Herbarium. George B. Cummins, Purdue University.—The Arthur Herbarium of the plant rust fungi had its beginning at Purdue University in 1887 when J. C. Arthur came to the institution bringing with him such collections as he had previously assembled. Until 1918 the herbarium was considered to be the private property of Dr. Arthur but in that year the herbarium was purchased by Purdue University and all collections of plant rusts received since that time have been considered to be the property of the University. The herbarium now consists of approximately 70,000 specimens from all parts of the world, including about 2,500 type specimens. The Arthur Herbarium is housed and maintained by the Department of Botany and Plant Pathology.

Two factors were of major importance in the early development of the herbarium. Firstly, Dr. Arthur was asked by the administration of the New York Botanical Garden to prepare the portion of the North American Flora which dealt with the Uredinales and, secondly, the rust research was given long continued financial support from funds appropriated under the Federal Adams Act in support of basic research in Agriculture. Since 1943 the work has been supported by Agricultural Experiment Station funds.

Charles C. Deam

Daniel DenUyl, Purdue University

To present a short summary of the life of Charles C. Deam is almost impossible because his life covered so many years filled with so much activity. These remarks stem for the most part from the many letters that he wrote. That his letters portray the man is well illustrated by one received from him in 1946 while he was in Florida: "Last eve before I retired I took up the Journal of Forestry to scan its contents and after reading one or two articles, I was too sleepy to read more when I came to the obituaries. Well, I could not pass these because in them were some old-timers I knew. I kept busy reading them and at last I turned a page and my eye first caught my picture and I said to myself: 'My God is Deam dead too?' I was not sure if I was dead or dreaming. I stood up and then sat down and when I read the headline, I was oriented.

"Well, Dan, I wish to thank you very much for this publicity although I know I am not worthy. You know I am just a common old plug rooting around with the boys. I try my best to keep out of the road of others and be friends with all of 'em. Plenty of room in this world for all of us which Hitler learned too late. You surely were not aware of the paper shortage or you would not have asked the Editor of the Journal to waste two pages on me. I did learn one thing by the write-up and that is, you should be careful of what you write in letters. You quoted a whole lot of low down on me. Moral, be careful of what you write but this comes to me too late to profit by it. One thing is true, my letters truthfully reflect my character O. K. I am just plain Charley Deam and I never want anyone to think anything else. The fact is, I do take a semi-annual bath to keep clean and occasionally do change clothes to be respectable (wife's doin's), otherwise, I am just plain old Charley Deam. I hope my life suits some, at least."

Now for an account of his life which began in Wells County, Indiana on August 30, 1865. To a friend he wrote, "I was born in 1865 two miles up the river from here. I grew up on a farm. I broke new ground when I was 13 and split rails for 120 rods of fence. My life was mostly work with an occasional day off because of a squirrel hunting desire that my father possessed."

After graduating from Bluffton High School he took a job teaching school. Of this experience he reports, "Three of the teachers had been thrown out before I came. I had to lick two boys who were bigger than I was. I licked four of them before I was done but I stayed."

Then came his two years at DePauw University. As he records it, "I ran out of money and so I quit college. Then, too, it took too much time." He did join a social fraternity, Delta Upsilon. In a letter written in 1952 to the widow of one of his fraternity brothers he expressed himself as follows: "It is hard to say an everlasting good-bye to an acquaintance, fraternity brother and classmate of 64 years. I will try to share your sorrow."

He started his career as a druggist in 1891 when he took a job clerking in a Bluffton drugstore. Of this he wrote, "I was able to save $80.00 in two years. During those years, I budgeted myself to spend 15 cents a week for Sunday School and church, 50 cents for foreign missions and $1 for something to read."

His purchase of a drugstore came about in a very unusual manner while he was a clerk in a Kokomo drugstore. His boss had the habit of standing in the doorway of his store, advertising the fact that his business was bad. Deam told him he shouldn't do it. One day, when Deam was out of the store, the owner and a salesman stood in the doorway talking. When the owner saw Deam approaching, he said, "Oh, I have to get out of the doorway. Charley Deam won't let me stand here." The salesman took an interest in this unusual clerk. Later he set Deam up in a Bluffton drugstore.

Of his early days as a business man he wrote, "I began business here in 1891 when the town had sixteen saloons, two houses of ill fame, one floor of gambling, one policeman, and one night watchman. Those days, we put a drunk out on the street with a ball and chain to his leg to crack rocks. Things were quite different than they are today. How things have changed since I went into business! We carried out the showcases to the sidewalk and scrubbed the floor every Friday night. Later, I was the first one to put linoleum on the floor. I was the first to give a clerk a week's vacation with pay. This sounds good to the clerks but the fascists may hang me. May the third of this year (1952), I shall celebrate my 60th year in business. While I have not been active in the store, I am as proud or prouder of being a conscientious pharmacist than anything I have ever worked at. What a pleasure and honor it is to be an intelligent, conscientious, obliging merchant. These three qualifications are or should be 'musts' in business."

During his long career as a druggist, he published Deam's almanac. A complete file, covering 32 years, has been given to the State Historical Society. The almanac is really a historical account of the early years of the drug business.

Deam fell ill from too long hours in his drugstore and too late hours studying, arguing, and debating with friends. Doctors advised him to get outside and so he began his outdoor walks. He wasn't content to just walk, so he began to study vegetation. When asked about his early botanical interest he said, "I had a buddy by the name of Bruce Williamson. He is in the largest part responsible for my life work. I was much older than he but I was about the only one available to go with him. We were together on two trips to Guatemala. Those were the days when I owned a drugstore."

An excellent summary of his early travels and other activities is contained in a letter written in December, 1951: "I was in the drug business and behind the counter 20 years and man, how I did work—like an idiot. Well, by the second year, my health broke and then I spent a vacation of seven weeks in Florida. I made a success of the retail drug business. In 1893 I married and in 1894 we vacationed in Florida. I had learned one must vacation to put in as many hours as I did. I was trying

to live on 4-6 hours sleep. This can be done but few people can take it and then only for a limited time. Since then, I take plenty time off but it is in the field.

"I was about 30 when I quit going to church and Sunday School. I knew more about the Bible, etc., than my teacher and I learned nothing so I just quit. Now, I go nowhere but to the woods and funerals.

I did make a few long field trips—to Mexico in 1896 and 1900 and to Guatemala in 1904 and 1909, each for three months. I made three trips to the Tennessee Highlands. I have botanized in every one of the 1,016 Indiana townships. So you see I have licked a lot of mosquitoes, picked up enough ticks to tell stories. I am deathly afraid of snakes so I first scan the field for reptiles and then plants."

That account gives a picture of his botanical and travel activities as well as revealing his fear of snakes.

A whole book could be written about his forestry activities which began with his appointment as State Forester in 1909 when Governor Thomas Marshall called Deam and asked him to accept the appointment. He told the Governor he was too busy in his store and could not accept. His friends in Bluffton who had been instrumental in having Deam appointed learned of his refusal and persuaded him to reconsider. Shortly afterwards, he was made State Forester. Deam relates that, "I went to Indianapolis. All the Governor did was to ask me if I was a Democrat. I didn't know I was State Forester until I returned to Bluffton where they put on quite a celebration." This wasn't the only time the people of Bluffton put on a celebration for him. Regarding one that was held in his honor in 1940, he wrote to me, "Think you know the business men here are giving me a testimonial dinner on October 27. You are invited and I want you to be here. You see they had this dinner brewing a month before I knew anything about it. The first I knew about it was when I read it in the paper. I was paralyzed but it had gone so far I could not get out of it so I am the ram led to the slaughter. Wish me good luck by coming over. Dean Coulter will be our guest and whoever he brings along. Since the affair is pulled, I want as many of my friends here as possible. Remember your invitation includes as many as you wish to bring. All you have to do is to keep your mouth shut and do not tell any mean things or shortcomings of mine. I do not wish to be debunked before the crowd. Otherwise, no limitations. All you have to do is to look wise and be still."

In 1943, when he was invited to join a group attending a forestry meeting in Michigan, he replied, "I regret to inform you that I must decline your invitation, principally because I am not physically able to make the trip. Secondly, I have been smoked out already too many times. Then, I can no longer hear a speaker in a crowd. Again, the meeting seems to be held so the group can see a football game which I do not attend. . . . I sure would like again to see old faces and the new ones as well but I would have to pay too dearly for the opportunity. Wife says the trip will kill me and the fact is, I cannot stand but one such experience."

In this letter and many others, he reveals his dislikes of smoking and

athletics. As early as 1911, he wrote in one of his diaries: "Today, I saw a young man pick up a playing card that was lying on the sidewalk, which many a passerby had stepped upon. He was smoking a cigarette."

In this same diary on May 22, 1911, he writes, "Stopped at Hovey Lake in Posey County with a Mr. Weatherford which reminded me of 'old times.' The "spare bed" was in the 'front room,' the floor was carpeted with the old hand woven carpet. The walls were papered and decorated with two enlarged pictures of deceased relatives. The room was furnished with a few chairs and a bureau on which was the photo of 'Tom Thumb and his wife.' Under the bureau was a small yellow chamber. On the floor in the corner was the family Bible. The bed had the old style large pillows with the red embroidered pillow cases." Apparently, his observations were not confined wholly to botanical fields.

His early experiences in forestry work in Indiana were interestingly summarized thus, "When I assumed the job of secretary of Indiana forestry in 1909, I was the boss and all hands with a so-called stenographer thrown in. Throughout my term of office, I kept a record of the first and second class mail I received each day and for that which was sent out. My recollection now is that the first week in office I received three letters, no second class mail. This lowly beginning reminds me of the anthropological finding that our modern horse's ancestor was a real miniature animal. We should be proud that the work in forestry is growing in Indiana."

Politics came into his activities as State Forester in 1912. A letter sent to him contained the following request, "Will you please be kind enough to prepare a list of the ladies of democratic families who are working in your office and mail to me at your earliest opportunity?" Deam's reply was, "I have your letter asking for a list of the ladies of this office whose parents are democrats. I do not know the purpose of such an inquiry and beg to learn if this is official business. I have never made inquiries of the politics of the parents of our stenographers but if by law, I am compelled to do so I shall proceed at once to make the necessary inquiry. If this is political business, I cannot regard your letter other than an impudent one." Apparently, it must have been political but Deam did not carry out the request.

Even in those early days the planting of trees on the stripped coal lands came to his attention. When asked to consider the problem one of his responsibilities, he replied, "I had enough to do without following them with a shovel and rake leveling the ground. They soon found out that only a level terrain would suit me."

He always took a very active interest in forestry affairs and was keenly interested in Indiana's forestry problems. An article in the Indianapolis Star in 1943 prompted him to write to me about the U. S. Forest Service. This letter not only gives an insight into his thinking but is an historical gem: "Well you may not know it but I have never been favorable to the U. S. Forest Service getting into Indiana. I fought them off while I was in office and they still would be out of Indiana if I had my way. I know I am prejudiced but it all came about in a natural way, too long to write here. I recall that one of the very first U. S. Foresters to call on me (cannot now just recall his name), but I met him

at the Clark County State Forest. When he got off the traction line car, he swaggered over to me with a brief case. You may be old enough to recall when 'dandies' and the 'uppercrust' made themselves conspicuous when the tooth brush came into existence. Then they would carry a tooth brush in their vest pockets, especially to church, etc. Later another badge of distinction came in (the fountain pen). Then we had to save our money to buy one, probably about a dollar. Sometimes, the high toned would have a tooth brush and a fountain pen. Then came the brief case (the modern carpet bag). Every guy of authority presented himself behind a brief case. Well, I detoured a little but that guy who came to see me at Clark County Forest had rings in his ears and one in his nose. He told me he had hayfever. Too bad he did not know enough not to be led by this superstition. We walked up thru the 'park' and when we came to a catalpa tree, he asked what kind of a tree it was. Then I was through. I soon found out while I knew nothing about forestry I was to teach him. Others of his like came. . . . I once called on the Chief Forester. While I was a caller, he sat at his desk with his number 10 feet on top of the desk and he leaned back in a swivel chair and smoked a pipe. He had a half gallon jar of tobacco on his table. Well, you know me as well as anyone. I am no sport but I do and always have had the sense and dignity to receive a State Forester with the dignity that the occasion demanded. When I was in office I always ceremoniously received everyone with as much courtesy and dignity as I could. I still believe in that, especially when people are strange to you. Of course, I would not now expect you to apply such rigid rules to me. But to be brief, I had no use for the Super Service. I know that the U. S. Service has a lot of very highest grade men."

One who understood, can appreciate Deam's attitude toward the Forest Service because it seemed as if most of his official dealings were with those who smoked—a thing which he always disliked and one of the things by which he judged people.

That he was an independent thinker who possessed a very keen sense of humor, as well as being an unusual person with some queer notions and one who was a great influence on those who worked with him, can best be summarized by a series of quotations from his letters.

To one of his friends, he wrote, "I have your letter and I am glad to learn you are still making trouble on the face of the earth."

A request to another: "Will you please bring me $2.00 worth of gold fish, assorted sizes? Our town does not sell them. I'd prefer to have them delivered alive."

"The honey came yesterday. What am I going to do with you? I am already deeply indebted to you and here again you add to my debt. I told the Mrs. that I was going to send you a check but she said no. I take her intuition for horse sense and just say thank you."

"I don't give a rap what happens or how I look. I dress to please the Mrs.—and shave so I will not be mistaken for a dog and be shot. Wife is also a legislator. I just got orders to wear my teeth all the time. I have been in the habit of resting them to avoid constant irritation. Maybe I can violate the edict to some extent. These darned teeth irritate me. You

know some people do play solos with their teeth much to the disgust of the audience. I guess that is my problem to make a noise with them *so low* as not to be heard. Here's hoping!

"My eyes are about out. I go tomorrow to see the oculist to see if anything can be done. There are two loads of manure just hauled in and I will now go out and toss it about. Guess this will not hurt my eyes as much as my muscles." This was written when he was 83 years old.

To one who sent him some tree seedlings for his arboretum he wrote: "Seedlings came in excellent condition and planting conditions fine. I did the job myself with my little spade. I heard one little seedling say, 'I'm glad they sent me to Deam because if I had been sent to some farmer, I would be sawed up when I reached my prime but they tell me Deam will keep me until I die and he will provide me an old age pension.' "

Many were his comments on the planting of multiflora rose. Here is one of them, "I understand they are strongly recommending now that all the old cemeteries be planted with multiflora rose. When Gabriel sounds his horn I am afraid some will be stranded and not be able to get thru the roses. Please do not recommend the multiflora rose except for the bonfire."

This next quote fits the present because it was addressed to Professor Kinsey. "Yes, I remember the time you compared me to an insect and tried to make me believe that the insect knew more than I did. I am now getting so old that I have no mind so I guess you win. In the meantime, we are all anxiously awaiting that 'Girl Book' you are working on."

Many were those who wrote to him about plant materials and published information on plants. His opinions were usually frankly and interestingly worded. After receiving a letter from a botanist who commented on Muenscher's new book, Deam answered, "You know one of the difficult things to do is to think and not let your prejudice influence you. I, personally, do not like him. It seems to me that the book is a most excellent one. So far, I have only one criticism, that is, omissions. I can't think that was ignorance on his part but just pure damned egotism. I think it might be well for somebody to dress him up a bit, and put the old boy where he belongs."

A friend wrote to him about Fernald's death and this is a part of his reply, "We have had great botanists in these United States but in my estimation Dr. Fernald was the greatest of all. Do not expect everyone to accept his findings. This would make him perfect, which he doubtless would repudiate. His general sin was being conservative."

Shortly after the new Gray's Manual was published, three botanists visited Deam. About this visit he wrote, "This week I had as guests, Professors McFarland, Steyermark and Swink. I regret their visit was short so we did not prune up Fernald the way we wanted."

In another letter he comments, "I confess I have not been able to study the Gray Manual very much. You already know I am a darned fool on a lot of this 'hooey' botanical names. I have permanently put the hyphens in moth balls. I, at present, am fluctuating between high and low blood pressure and when I read the Gray Manual, 'calyx-lobes' my blood begins to boil. Do not misconstrue me—I think the world of Fer-

nald and I admire conservatism but it must not be tied to ignorance. I cannot understand why Fernald uses the hyphen between the words just mentioned but not to use it between like words."

This last quotation about hyphens illustrates one of his own problems in the revision of "Trees of Indiana." Prior to 1944 he discussed with me the revision which he had already started. However, in November, 1944, he wrote, "I have given up the revision because of my health" and then this long letter contained details of what he intended to do. Later he wrote, "All I can say is that I am going ahead as fast as I can but my first effort is going to be to revise and bring to date all that I have written."

That he had many physical and mental problems during the time that he wrote the "Trees of Indiana" is well illustrated in one letter,— "Guess I will quit writing on forestry and start to write political platforms, that is where you write something and nobody knows what it is about. Now here is what I had in mind. Let botanical authors publish their writings in recognized botanical magazines and not hide them in some obscure journal and be overlooked and in a hundred years we may have a new name."

When the manuscript on Trees was completed and sent to Indianapolis, his desires to have the material correctly printed are shown in his letter of instructions which contains the following: "I write you this note as a suggestion and stimulus to meet the printer when you present the galley proof to him with the numerous corrections to be made but do not let them talk you out of making them. . . . It is not necessary for me to point out errors all of which you know better than I do. I am surely much pleased to learn that I have such an able helper. The Lord knows I am in the lower brackets when it comes to publication but I do have some ideas of my own which I hope I may realize on." An appeal to secure action on printing the tree book is well stated when he said, "For my sake, please hasten the appearance of the proof and God will take care of the other items."

To one who had written to him about his revision, he replied, "I call your attention to some of the major novelties for fear I shall not be here when the book is published, if ever."

His realization of his limitations are contained in one of his letters of warning: "I have warned you that my health is going fast (at 87 years of age). Remember I still have the index to write after I get the page proof and my brain does not function as it did when I was fifty years old."

Deam liked to get out in the fields and woods to study plants. One of his letters about a field trip begins, "You are hereby subpoenaed to appear at Bluffton, Indiana on or before August 28 to act as chauffeur for a decrepit old man who wishes to collect Helianthus." He also expressed his desire to get to the woods thus: "I feel like never going to the woods again. But my desire to get out seems to be perennial and as soon as I feel better I want to go to southwest Indiana. But the date is so far in the future that it is now only a dream. I make no engagements for the

distant future. I am always glad to get out to the woods. I wish I could stay there and have my meals brought to me."

With advancing years Deam became very much concerned about his health. He expressed this concern in some very unusual ways. In 1951 he wrote, "I regret to inform you that I am down and out. Tuesday, I spent $33.50 at the hospital. They gave me a blood transfusion and said I would feel like a fighting rooster. I misinterpreted this because I feel like a rooster that was all pecked to pieces. I am very weak and can scarcely walk. Fortunately, I do not have a pain or ache. After being examined at the hospital for everything except ingrown toe nails, they say I am suffering from nutritional anemia." In another letter, he says, "Old Man Deam is about to pass on. My health is very bad. I have run out of gas. I fatigue very quickly and too my cerebral hemorrhage (parlor name for stroke), last July affects me very much. Too, my eyes are weak and I miss them very much."

An interesting description of his physical condition and growing old was written by him in 1950: "The material in our arboretum (most of it) is now old enough to vote. I know you will be surprised to see how fast it has grown and how Deam has grown old." In spite of his failing health he continued his botanical work and tried to keep in touch with those who had an interest in plants. He was very much interested in the Indiana Academy of Science. That he wanted to attend the meetings is expressed in a letter written several months prior to the 1950 meeting. "It is humiliating and irritating to go some place with a 'tar bucket' hanging on the coupling pole. Here is the same old tarbucket but in bad shape. Just received notice of meeting of Indiana Academy of Science and I am depending upon you to transport me. I can go and return any time. Now, I ask you to fill in the enclosed blanks to suit your convenience. For my meals I take fish but damn the haddock. We should be at the evening meal. As to bed, I do not care where except that I must sleep. Will you please remit for me and take chances that I will not forget it?"

Many more interesting and descriptive quotations could be given. They would help to characterize him as a man who was a keen observer, an accurate recorder, a true scientist possessing an unusual mind, a keen sense of humor and a faculty for growing old—gracefully.

The shortest letter that I ever received from Deam will serve as my summary. In February, 1952 he wrote, "Your letter of January 22 is received. I have nothing to write only to tell you that I love you still." The last four words of that letter express my own feeling for our departed friend, Charlie Deam.

The History of Science at Earlham College

Millard S. Markle, Earlham College

The founding of Earlham College grew out of a concern common to Quakers for the education of their young people. The setting up of schools was coincident with the establishment of meetings for worship. The meetinghouse and the schoolhouse were often side by side, thus emphasizing the belief in an essential relationship between education and religion.

This relation became more specific at Earlham College in the recognition from the beginning of the fact that there is no discord between scientific education and religion. This came about not so much as the result of an established policy as through the educational contributions of members of the administrative and instructional staff of the college, who combined in their own lives and teaching an appreciation of nature through a thorough knowledge of science and a simple and sincere worship of the Creator. While on leave for graduate study at Harvard University, Joseph Moore wrote, "In my pursuit of science may I be constantly inspired by the highest motive—that of learning more of God as He has displayed Himself in all that He has made. God is the author of truth and how can we be better employed than in searching into such things as He has given us the power and a longing to investigate. The universe is the work of the divine mind. Since omniscience is one of his attributes, the man who knows the most is in this respect most like his Maker."

From the beginning to the present time, a considerable proportion of the teachers of science have been recognized ministers of the gospel of the Society of Friends, while the most of the others have been active religious workers.

The fact that this synthesis was recognized also by the teachers in the Department of Religion made it possible for students to go from classes in one department to those of the other without being confronted by mutual ridicule and antagonism that have characterized these two departments in many educational institutions. Evolution and "higher criticism" may have troubled some of the patrons of the college, but not the students.

From its beginning Earlham College has given prominence to the sciences. Joseph Moore was a student of Agassiz, a charter member of the Indiana Academy of Science, instructor in science at Earlham 1853-65, president 1868-83 and curator of the Museum 1885-1905. He did more to establish the pattern of this unity of religion and science than any other man. The museum, which began as a collection of minerals in a small cabinet in his student days, was actively expanded into the best college museum in the state. The mastodon, its most spectacular specimen, and the fossil beaver, Castoroides ohioensis, its most valuable one, and until recently the only one in existence, were added about 1896. By this time the museum contained 14,000 specimens.

As the college grew and science expanded, he brought to the college men like David Worth Dennis, for whom was named the building we now occupy and who, in taking over the most of the work in science, taught physics, chemistry, geology and biology. I have heard him say that he did not occupy a chair of science, but a settee. He exemplified the breadth of knowledge and interest not uncommon in the best teachers of that time, but largely lost in our present period of specialization. He knew not only science but literature and art. He was a minister of the gospel as well as a teacher and simply and reverently combined in the classroom the functions of both teacher and preacher. I came to Earlham from a conservative Methodist family, quite convinced that Darwin was a name to be mentioned with righteous horror. In his classes I was led to think constructively and to bring my religious and scientific attitudes into harmony without mental and spiritual anguish. For thirty years he was a member of the college faculty. He was a leader and founder of the Indiana Academy of Science, an organizer and supporter of the Indiana Audubon Society, having been a member of the committee set up by the Academy to organize the latter group. He taught birds and trees in field courses, when that method of presentation was new. He preached the gospel of field work in teachers' institutes all over Indiana. Teachers from all over the state came during summer terms to learn his methods and to catch his contagious enthusiasm. Among his hobbies were photography and photomicrography. In collaboration with Dr. Charles Bond, of Richmond, who is still living, the best Zeiss apparatus was purchased. Both men spent long hours late at night adjusting the complicated apparatus and making photomicrographs, which became well known. Early in the history of microscopy, microscopes were in use by students of biology.

The Department of Geology had its beginning when Earlham was the Friends Boarding School. The first catalog, issued for the year 1857-8, gives geology as one of the natural sciences. In 1902 it was recognized as a separate department. In 1900, Allen D. Hole returned to his alma mater, to be Professor of Geology and Curator of the newly-named Joseph Moore Museum. Until his death in 1940 his classes in geology were well attended and much appreciated. He excelled as a teacher. Summer after summer he combined research in glacial geology in southwestern Colorado with instruction in field geology to small groups of students, later taking larger groups to the Grand Canyon and Yellowstone Park. His special interest was the training of students to take positions in the United States Soil Survey. At one time approximately one-fourth of the members of the Soil Survey were Allen Hole's students. Mark Baldwin, Earl Fowler and James Thorp became leaders, the last-named returning recently to take the place of his former teacher as head of the Department of Geology.

The Division of Natural Sciences has had fewer changes in personnel than any other division of the college. Joseph Moore was connected with the college for forty-five years; David Dennis, thirty-two years; Allen Hole, forty years. The five present teachers of longest service have been active for an average period of thirty-five years.

Other teachers who at an earlier period left their mark on the college were the following: Dr. Harry N. Holmes, who was Professor of Chemistry 1907-14, is Professor Emeritus of Chemistry at Oberlin College. Dr. Wm. D. Collins, Professor of Physics 1897-1907, recently retired from the United States Geological Survey. Dr. Robert L. Sackett, Professor of Mathematics 1891-1907, was for many years at State College, Pa. Dr. Raymond Binford, Professor of Biology 1913-18, was called to the presidency of Guilford College. Dr. Elmer D. Grant was Professor of Mathematics from 1920 to his death in 1935. Dr. Wm. O. Mendenhall, Professor of Mathematics 1907-18, became president of Friends University and Whittier College. Edwin Morrison, Professor of Physics 1906-19, went to Michigan State College. Dr. Martha Doan was Professor of Chemistry 1915-26.

In earlier years Earlham was well known for the training of public school teachers. Throughout its history it has given undergraduate training to large numbers of physicians and dentists.

A survey of the graduates of the college, along with many others, was recently made by members of the science faculty of Wesleyan University, at Middletown, Conn., in an effort to ascertain the undergraduate origins of American scientists. The index which was used was the rate per thousand at which male graduates of the years 1924-34 in the various institutions continued their education to the doctoral level and were listed in American Men of Science. Among the colleges and universities of the country, Earlham ranked fourth.

Until recently the departments of natural science have never been adequately housed. The departments were scattered over the campus in cramped, poorly-equipped quarters. Plans were being made for a science building when, in 1924, Lindley Hall, the principal instructional and administrative building of the college, was destroyed by fire. Its replacement by the present Carpenter Hall made necessary the postponement of the erection of a building for the sciences.

In 1952 the departments of the natural science division moved into David Worth Dennis Science Hall, with great improvement in space and equipment, including quarters for the Joseph Moore Museum. The instructional staff is mindful of the fine work done in earlier days, with poor housing and makeshift equipment and addresses itself humbly to the task of building upon the firm foundations which have been laid and the traditions which have been established.

History of Science Work at Hanover College

Earl Martin, Hanover College

Scientific work at Hanover obtained its start at the very beginning of the work of the institution. Dr. Crowe came from the scientific atmosphere of Transylvania College to found Hanover, and later to become the grandfather of the Coulters, John M. and Stanley, two of the brightest stars in the scientific constellation of Hanover. James Blythe, the first president of Hanover, was formerly professor of Chemistry at Transylvania. These men brought to the College an enthusiasm for and an interest in science that has greatly influenced the work at the institution.

Since the founding of Hanover College in 1827 much emphasis has been given to the promulgation of the various sciences. Although the College was founded by the Presbyterian Church for the education of ministers for that denomination, it was recognized at the very beginning that science should form an important part of that education. Consequently we find in the curricula of the College in those early days all of the current scientific subjects.

The methods of teaching science at Hanover have changed since its founding, but always the methods have been those which were current in similar colleges if not somewhat in advance. It is recorded in former President Millis' "History of Hanover College" that that institution took the lead in several phases of the development of our present methods of teaching science. On page 213 of that book we find the following quotation: "Professor Young came after Coulter and has the distinction of introducing into Indiana the practice of teaching Chemistry by the laboratory method."

Also, Hanover is given credit by Dr. Millis of initiating the use of field trips in the study of both geology and botany. A practice which has been expanded not only at Hanover but in practically all of the first-class colleges of the country.

The teaching of science, so far as the method is concerned, seems to have gone through the following three stages: First, the text book-teacher phase, in which most of the sciences were taught by the same teacher. All of the courses were elementary in nature. A good text book for each science was selected and the material in that book plus the contributions of the teacher formed the essence of the course. Students were required to master most of the details of the subject as set forth in that text book. This method of instruction extended from the beginning of the College in 1827 until about 1869.

The second phase, for want of a better name, we will call the beginning of the modern methods of science. This period began with the coming to Hanover of Professor A. M. Bradley in 1869. Professor Bradley, fresh from the halls of Yale University, was enthused with a zeal for the teaching of science for the sake of science as he understood it. He was well trained, enthusiastic, undiplomatic, fearless and determined. Are these not the chief characteristics of the modern scientist? Professor Bradley soon found himself at odds with the Board of Trustees; and when he

refused to admit that the earth did not come into existence until about 6000 years before the birth of Christ, he was summarily dismissed after one year's service. Bradley subsequently accompanied Major Powell in his explorations of the west, notably, in the exploration of the Grand Canyon of the Colorado. As an outgrowth of this exploration, the U. S. Geological Survey came into being.

Bradley was a martyr of his science, but he remained long enough to plant not only the seeds of scientific thought at Hanover, but also to initiate the new methods for the development of that scientific work. Let us say right here that the experience of Bradley with the Trustees at Hanover is the only recorded instance of an infringement on academic freedom at Hanover in its existence of more than a century and a quarter. Had Professor Bradley been a little more diplomatic and amenable to reason, that long period of academic freedom might never have been broken. Today, as in the past, there is complete freedom of expression in science as in all other courses at Hanover.

Professor Bradley was followed at Hanover by Dr. E. Thompson Nelson, also from Yale. While quite young and inexperienced, Dr. Nelson had the vigor, resourcefulness, and zeal for science to carry forward the work of Bradley. He remained at Hanover only a few years, but during that time some of the real giants of science not only in Indiana, but also in the nation were developed. Dr. Harvey W. Wiley, the father of the U. S. Food and Drug Act, finished his formal education here. Dr. John S. Coulter, who was to lead the work in botany at the University of Chicago for so many years; Dr. Stanley Coulter, the nationally known Dean at Purdue University for almost half a century; Dr. Harvey A. Young and Dr. Glen Culbertson, who were very effective in their science work at Hanover, all graduated from Hanover during the early days of this period. Surely this was a productive period in scientific work at the College.

The methods of teaching during this period were characterized by use of a good text book in each course, contributions by the teacher in lectures and classroom, laboratory work, field trips, museum and science club work. The above was supplemented by a number of all-college lectures given by well known scientists from off the campus.

The first laboratory for the teaching of science at Hanover was in the basement of old Classic Hall. There with the crudest equipment Professor Young and his colleagues set the stage for the experimental work in college laboratories in Indiana. Their early work was recognized by the Trustees of the College who furnished them with a new building for the science department at Hanover. This new building was dedicated in 1897. It is worthy of note that three of the speakers at the dedication exercises were sons of Hanover's scientific work; Dr. Harvey Wiley, Dr. Barnes, and Dr. Stanley Coulter.

Up to about 1880 teachers of science were listed in the College catalogue as Professor of Natural Science. After that date, we find they were listed as Professor of the subject they taught. With the addition of more and more teachers of science, the number of courses offered in science increased, but nowhere do we find specialization, such as is found in the system of majors and minors now prevalent in most colleges, until about 1925.

The third and present phase of the teaching of science at Hanover began about 1925 when separate departments were set up and properly staffed for a number of different sciences. Lecture rooms, classrooms and laboratories were provided for each department. Enough courses were offered to give majors and minors in each of the sciences in the curriculum.

In 1919 the science building was destroyed by fire, but the College built a new building at once, and the work in science continued. This second building was built at a time when the funds of the College were low. It was made fireproof but was not very well adapted to the work of science. Space will not permit a detailed discussion of the inadequacies of this building, however, the writer of this paper taught physics in it for eighteen years and can assure the reader that many things were lacking.

In spite of the poor building which housed their work, the men teaching in the field upheld the reputation of the College in scientific instruction and development, as is evidenced by the large proportion and academic standing of the students who have specialized in science and have gone on to other institutions for higher degrees.

Immediately after the second World War, the College built among other structures the present science building, Goodrich Hall. This building, together with its equipment, would cost today almost one million dollars. It is well equipped for the teaching of all of the sciences. It houses the departments of Botany, Chemistry, Geology, Physics and Zoology. Full majors are now offered in each of these fields. Much should be expected in the field of science in the coming years.

Of the 600 students now enrolled at Hanover there are 1182 different registrations for science courses. This registration of two courses on the average for each of Hanover's students should indicate the emphasis on science. The majors in science comprise approximately 50% of the graduating class each year.

The science faculty during the years has numbered at least a total of 43. Seven of these served during the years when one man taught several different subjects. Outstanding in that group was Dr. S. Harrison Thomas, Professor of Natural Science, Mathematics, and Mechanical Philosophy, from 1844 to 1877.

In the second period, when the work was divided up among more teachers, and the laboratory, museum and field trips supplemented the classroom, we find at least eighteen different teachers taught science at Hanover for one or more years. In this group are recorded the best known teachers of science that Hanover can claim. Such men as Dr. John M. Coulter, Dr. Frank L. Morse, Dr. Harvey A. Young, Dr. Glenn Culbertson, and Professor Leonard Huber. In fact the names of all eighteen of these men are prominent in Hanover's science teaching.

Now during the third period of science instruction, when the work in each field became the responsibility of one or more teachers, Hanover has had at least twenty different teachers in the science faculty. This period is now in the making. We are too close to judge it properly. No one name stands out very much above that of several others. The excellent work that has been done during this period is due, in part, to the long tenure of some of its teachers. Professor Joseph L. Hyatt served as

Professor of Zoology for 24 years before retiring in 1952. Three of the other teachers, Professor Grant T. Wickwire of the geology department, Professor Ned Guthrie in chemistry, and the writer, Dr. Earl Martin in physics have each served the College over 24 years. Their combined service is 80 years and it appears that before they retire their combined service will exceed 100 years. Several others in this group have made an enviable record.

While the chief emphasis at Hanover has been on the teaching of science courses, it should not be inferred that no thought or effort is given to other aspects of science education. From the days of Bradley and Nelson on down through the years to the present, extensive research work has been carried out, papers published, and articles contributed to scientific journals. Science teachers have been regular attendants at state and national meetings and conventions. Some of them have held offices in these organizations. More than one Hanover faculty member has been president of our own Indiana Academy of Science. The Botanical Gazette was founded at Hanover. Laboratory work in science, field trips, and a geology museum all had their beginnings in Indiana at Hanover.

Looking back over a roster of the alumni of the College we find the names of many men and women in various activities who have gone out and made an enviable record in their chosen field. This is especially true in the field of science. Mention has already been made in this paper of the work of Harvey Wiley, Stanley Coulter, John Coulter and others. Let us add to this list of men developed during the first period of science teaching the name of Dr. Amos W. Butler of the class of 1877. The four scientists just mentioned were among the giants of their day who founded the Indiana Academy of Science. Each of these men afterwards becoming president of the organization, John Coulter being the second president. Many other prominent alumni of scientific note could be mentioned who were developed during the first period of Hanover's scientific work.

During the second period of scientific culture when laboratory work, field trips and the museum had been added to the curriculum, a number of outstanding scientists were trained. To name only a few:

Leonard Huber, professor at Hanover College.
Guy Campbell, nationally known geologist.
Harold Voris, prominent brain specialist of Chicago.
Archer Culbertson, chief geologist for Continental Oil Company.
Ira S. Allison, professor at Oregon State College.
Rachel Hoffstadt, professor at University of Washington.

During the third period of science teaching at Hanover when full majors were offered in various sciences, a relatively large number of the graduates have been men and women who have specializd in some field of science and have gone on to further work in their chosen field. Since these people did not graduate until after 1930, their record is just in the making. Several of them give promise of a very successful future. Only a few will be mentioned here for lack of space.

Clifford Adams, professor of Geology at Hanover College.
Clarence Boyer and Louis Huber, physicists with E. I. Dupont Co.

John Taggart, chemist with Eli Lilly Company.
Paul Suit, physicist with Lockhead Airplane Corporation.
Dwight Lindsay, professor of Biology, Georgetown University.
Phyllis Fleming, professor of Physics, Wellesley College.
Louise Plummer, professor of Chemistry, Beaver College.
Roger Williams, geo-physicist, Gulf Refining Company.
William Hill, physicist, General Electric Company.

This list might be extended considerably if space permitted. Perhaps it is sufficient to indicate that Hanover College in recent years has continued to make its contribution to the field of science. We who are teaching and working at Hanover expect this contribution to increase as time elapses because of the expanded facilities and faculty in science.

Whatever contribution that Hanover has made in the field of science is due in a large degree to the environment in which the work was done. This environment, in addition to the natural setting of the institution, has been largely due to the sympathetic and systematic efforts of the administration of the College, both to the presidents and to the boards of trustees. Throughout the years they have made it possible for the teachers of science to carry out their work unrestrained by anything that could hamper their efforts.

The Academy's John Shepard Wright Memorial Library

Nellie M. Coats, Indiana State Library

The Academy's first constitution, December 29, 1885, provided for a librarian who should be an officer, a member of the Executive Committee, curator of the museum, and who should distribute, sell, and exchange the society's publications. By-laws set aside one-fourth of the Academy's income for the increase of the library. John N. Hurty was elected as this officer.

No argument for the action is recorded in the minutes but at the December, 1886, sessions, amendments struck out all references to a librarian and his duties, and to an income for a library. In 1887 a committee was appointed to urge the purchase of rare and valuable scientific books by the State Library, and shortly after the Academy unsuccessfully promoted legislation to place an Academy member on a State Library book selection board. In reporting this activity the committee noted that a request for certain information had been addressed to the state librarian, J. P. Dunn. What is the amount appropriated for books; who are members of the purchasing board; what amount has been expended to date; for what; give departments of knowledge; amount expended in each category; by whom were titles recommended; any other facts? (I submit that such gad-flies are good for institutions.) The librarian had replied that he himself had chosen most of the books and that most of them were histories. The Committee felt that if specific recommendations were made, up to five hundred dollars a year might be spent by the State Library for books in the various fields of sciences. The next year's State Library report listed such purchases as: Say, American conchology, $12.00; American naturalist, 22 vols., $50.00; Journal of the Cincinnati Society of Natural History, 11 vols., $30.00; Fische der Süd See, pts. 1-6, $83.29; Pownall, Topographical Description of North America, $18.00.

In this year, 1890, a campaign was begun to permit publication of the Proceedings as a public document at state expense. A committee on the Academy's relation to the state reported in May, 1895, that the 1895 General Assembly had enacted such legislation, legislation which, with minor changes, is in effect today. Section 3 of the Act carried these provisions:

> "All except three hundred copies of each volume of said reports shall be placed in the custody of the State Librarian, who shall furnish one copy thereof to each public library in the State, one copy to each university, college or normal school in the State, one copy to each high school in the State having a library, which shall make application therefor, and one copy to such other institutions, societies or persons as may be designated by the Academy through its editors or its council. The remaining three hundred copies shall be turned over to the Academy to be disposed of as it may determine. In order to provide for the preservation of the same it shall be the duty of the Custodian

of the State House to provide and place at the disposal of the Academy one of the unoccupied rooms of the State House to be designated as the office of the Indiana Academy of Science, wherein said copies of said reports belonging to the Academy, together with the original manuscripts, drawings, etc., thereof can be safely kept, and he shall also equip the same with the necessary shelving and furniture."

A list of foreign correspondents, i.e. an exchange list, was published in the 1896 Proceedings and such listing was continued through 1904. Thirty-two countries were represented in 1896.

A tentative agreement between the Academy and the State Library was presented in 1898 which would give custody of Academy materials to the State Library to be kept as a separate collection and to remain the Academy's property, an arrangement which could be terminated upon ninety days notice by either party.

The next year the Brookville Academy's library was acquired and the expediency of cataloging the books in the State Library was investigated.

In 1900 there was further discussion about the disposition of the library, whether it should be placed in the State Library or in a secure room in the State House. Fifty dollars was set aside for cataloging.

In 1905 a proposal from the State Librarian, W. E. Henry, that the State Library buy shelving for the Academy Library was presented but was not avidly received. It was voted to confer with Mr. Henry and report at the winter session. At this point it was suggested that a log cabin be built at Woollen's Gardens. The relation between these ideas is not clear. There had been some hope that a Carnegie building fund might be acquired. The Committee on State Library strongly recommended the acceptance of the Henry proposal saying that the State Library would provide shelving and safe storage for rare and irreplacable material owned by the Academy, a collection rich in monographs and reports of learned societies from all lands; that no complete classification had been made nor any systematic effort toward completing files of serials, that these materials were unavailable for lack of binding, classification and proper library supervision. To provide these services independently would cost more than the Academy could hope to raise. The Library should be in custody of a permanent institution under skilled and impartial management. The Academy should retain ownership and reimburse the State Library for its outlay in cataloging and care. A Committee report in November, 1905, added to the earlier proposal a proviso that the State Librarian should report the annual outlay so that the Academy "might provide a sinking fund for the redemption of its property," and that the Academy should be entitled to the catalog cards as well as to the volumes in its collection. A slight revision of this 1905 arrangement was made in 1907 and the contract now in force agreed upon and signed by the State Librarian, Demarchus Brown, and John S. Wright, chairman, Academy Committee on the State Library. The agreement follows:

The State Librarian to accept the present collection of the Academy of Science as a deposit with the State Library, on the

following terms: The State Library shall classify, as fast as time and funds permit, make a separate card catalogue and organize the Academy collection into said library as a part of the same, and care for it in every way as it does books and pamphlets purchased by the State Library with the understanding that the books and pamphlets are to be taken from the library by the members of the Academy, but used as reference works by the public, provided, however, that the State Library shall not catalogue and shelve United States government publications belonging to the Academy that are duplicates of publications already catalogued and shelved, or that shall in future be received by the State Library from the United States government; but all such duplicates shall be stored separately in the store room of the State Library and shall be subject to the control of the Academy.

Complete volumes, either books or periodicals, shall be bound in cloth at the expense of the State Library, as fast as funds are available without neglecting the work of the State Library in lines already established.

The State Library will make all reasonable effort to complete by exchange for the Academy of Science all incomplete sets of publications, being free to use for exchange purposes all publications of the Indiana Academy of Science except the three hundred reserve, which shall not be used except with the consent of the President and Secretary of the Academy of Science.

In classifying and cataloguing this collection, there shall be kept a separate card catalogue or shelf list and each volume or pamphlet belonging to the Academy of Science shall be so marked on its title page with an embossed stamp furnished by the Academy of Science.

In consideration of the expense of this collection to the State Library, it shall not be removed from the State Library by the Academy of Science until said Academy shall have reimbursed the State Library for all cash outlay in binding, from the date of this contract until the date of removal. The Academy may, however, have the right to remove this collection on demand, accompanied by such payment, and upon such removal, shall be entitled to the catalogue cards belonging to such collection. The copies of the reports of the Academy shall be distributed to members at the Academy's expense but the library shall pay for all other expenses of distribution to libraries and state institutions and individuals other than members. This agreement shall terminate upon twelve months notice by either party.

At a later date permission to loan material to the general public was granted.

Cataloging by the State Library staff seems to have been carried on consistently and in great detail, up to 1930 the listing by author and subject of articles in specific journals amounting to indexing, making

the material extraordinarily accessible. A good deal of binding was done by the State Library but lack of funds and lack of space hampered that institution. Academy committees were asked to advocate legislative action for a State Library building, for which an appropriation was made in 1929. The building was occupied in December, 1932. Space was assigned the Academy Library in the stack area with some small allowance for growth.

Early in 1935 the exchange lists of the Academy were assigned to the Catalog Division of the State Library where records of serial receipts were kept, and the head of the Division assumed the title of Academy Librarian. At the time of transfer the Academy Library contained 1,030 bound volumes and some 10,000 unbound serial items. So much checking was needed that a grant was made by the Academy to employ a trained librarian temporarily to bring the mailing lists up to date, to coordinate distribution with receipts, to complete serial files so far as possible by appeal to issuing agencies. Six hundred issues were received and much biblographical information supplied which aided greatly in recording material correctly. Reply cards were adopted to keep mailing lists up to date.

In 1936, the funds of the State Library proving inadequate, the Academy began an annual allotment for binding.

The Academy editor in 1937 asked that the State Library be considered Academy headquarters and a permanent address for the officers. The Proceedings have carried a note to that effect since.

Growth was slow during the war years but with the restoration of European and Asiatic exchanges the Academy Library was again in need of space. In 1950, with the removal of certain state offices, the State Library found it possible to set aside as special quarters an area, for which the State Library purchased five hundred sixty linear feet of steel shelving, and an adjoining office, furnished from a John S. Wright fund, assigned the Academy. In 1952 in recognition of long standing interest and substantial support the library was designated The John Shepard Wright Memorial Library of the Indiana Academy of Science.

Throughout, the Academy has shown an interest in expanding the subject and geographic range of its library and in making the holdings more available and better known. Probably one of the first union bibliographies in Indiana was the Catalog of scientific periodical literature on file in the various libraries of the state published in the 1911 Proceedings, revised, enlarged, and issued in the 1913 Proceedings. Twenty-seven hundred titles in nineteen libraries were recorded. A list of the Academy's current titles and holdings of these was distributed to members and to Indiana's interested libraries in 1935. The latest list to be processed for this group was issued in 1949.

All serials held by the Academy were listed in the Union List of Serials in Indiana Libraries in 1939, and repeated in the Union List of Serials in Libraries of the United States and Canada in 1940. Added holdings were checked for the 1941-43 and the 1944-49 supplements to this national list. Current exchanges are now reported regularly to the Library of Congress for its monthly New Serial Titles, a union list.

Eight hundred two serial titles are currently received and there are four thousand six hundred forty bound volumes, chiefly serials, in the library.

At the present time the State Library supplies office and stack space, shelving, processing equipment, and janitor service. It receives and distributes the Proceedings to members, to Indiana libraries and to institutions on the exchange list. Such special publications as the Academy's Index, vols. 1-50 and Visher, Indiana Scientists are also mailed by the State Library.

New national and international listings of serials issued by scientific and technical institutions or societies are scanned and offers to exchange publications are forwarded. Mailing lists are kept up to date. Serials received are cataloged, classified, recorded, and prepared for binding. The reference and loan use of the library is supervised. Participation of the library in national bibliographic projects is assured and much painstaking checking done in this field. Exhibits of interesting and important new publications are at times prepared for annual meetings of the Academy. The Academy library is represented at sessions of the national and local associations of special libraries.

For the last several years the member of the State Library staff who serves as Academy Librarian has been appointed chairman of the Library Committee, an appointment which carries with it membership on the Budget and Executive Committees, an arrangement which permits a greater and more useful knowledge of the Academy's policies on the part of a headquarters staff and approximates the intent of the first constitution of the society.

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Indiana Nobelists and National Academy Members

STEPHEN S. VISHER, Indiana University

Four Indiana scientists have been awarded Nobel Prizes (recently about $33,000 each): Herman J. Muller (born 1890), genetic zoologist; Edward M. Purcell (b. 1912), atomic physicist; Harold C. Urey (b. 1893), physical chemist; and Wendell M. Stanley (b. 1904), biochemist. Urey and Stanley are natives of Indiana, born in Walkerton (St. Joseph County), and Ridgeville (Randolph County) respectively. Purcell and Stanley are collegiate graduates of Purdue University and Earlham College respectively. Urey was started at Earlham, inspired by the distinguished chemist, Harry N. Holmes, professor there 1907-1914. (Urey left Earlham when Holmes went to Oberlin.) Muller was elected while a professor at Indiana University; Purcell was elected while a professor at Harvard; Urey, as a professor at Columbia, and Stanley while with the Rockefeller Medical Institute. All four Nobelists continue active in research and advanced teaching at Indiana, Harvard, Chicago, and California (Berkeley) respectively.

Twenty-one native Hoosiers have been elected to the National Academy of Sciences, recognized the world over by scientists as a very high honor: Warder C. Allee (b. 1885), ecological zoologist; Charles P. Berkey (b. 1867), geologist; John S. Billings (1838-1913), pathologist; Herbert E. Carter (b. 1910), chemist; Arthur C. Cope (b. 1909), chemist; Lee A. DuBridge (b. 1901), physicist; Charles A. Kraus (b. 1875), chemist; Frank C. Mann (b. 1887), physiologist; Ernest G. Merritt (1865-1948), physicist; William A. Noyes, Jr. (b. 1898), chemist; Francis W. Reichelderfer (b. 1895), meteorologist; Oscar Riddle (b. 1877), genetic zoologist; Vesto M. Slipher (b. 1875), astronomer; Lee Irvin Smith (b. 1891), organic chemist; Wendell M. Stanley (b. 1900), biochemist; Calvin P. Stone (b. 1892), psychologist; Frederick Terman (b. 1900), electrical engineer; Lewis M. Terman (b. 1877), psychologist; Harold C. Urey (b. 1893), physical chemist; Chester H. Werkman (b. 1893), bacteriologist, and Clark Wissler (1870-1947), anthropologist.

These 21 natives of Indiana were born as follows: Allee (Bloomingdale, Parke Co.), Berkey (Goshen, Goshen Co.), Billings (Switzerland Co.), Carter (Mooresville, Morgan Co.), Cope (Dunreith, Henry Co.), DuBridge (Terre Haute, Vigo Co.), Kraus (Knightsville, Clay Co.), Mann (Decatur, Adams Co.), Merritt (Indianapolis, Marion Co.), Noyes (Terre Haute), Reichelderfer (Harlan, Allen Co.), Riddle (Cincinnati, Greene Co.), Slipher (Mulberry, Clinton Co.), Smith (Indianapolis), Stanley (Ridgeville, Randolph Co.), Stone (Portland, Jay Co.), Urey (Walkerton, St. Joseph Co.), Werkman (Ft. Wayne, Allen Co.), and Wissler (Wayne Co.).

Four non-natives of Indiana were elected to the National Academy of Sciences while employed in Indiana. Ralph E. Cleland (b. 1892), genetic botanist; Carl H. Eigenmann (1863-1927), zoologist; Tracy M. Sonneborn (b. 1905), genetic zoologist; and Robert E. Wilson (b. 1883), petroleum chemist. Mr. Wilson was director of research for the Standard Oil Co.

of Indiana when elected; the other three were professors at Indiana University. No native Hoosier has been elected to the Academy while in Indiana. Six non-natives were elected after teaching in Indiana: John C. Branner (1850-1922), geologist; Douglas H. Campbell (1859-1952), botanist; John M. Coulter (1851-1928), botanist; Thomas C. Mendenhall (1841-1924), physicist; W. A. Noyes (1857-1941), chemist, and Burrhus F. Skinner (b. 1904), psychologist. Of these, Mendenhall and Noyes were at Rose Polytechnic Institute (Terre Haute), and Branner, Campbell, Coulter, and Skinner were at Indiana University. Coulter taught at Hanover and Wabash Colleges before becoming president of Indiana University. A former Eli Lilly employee, Homer W. Smith (b. 1895), chemist, was elected after leaving Indiana. Branner and Campbell were elected while professors at Stanford University; Coulter while professor at Chicago, Mendenhall while with the U. S. Coast and Geodetic Survey, Noyes while professor at Illinois, Skinner while professor at Harvard, and Smith while at New York University. Of these Academicians, those still active in 1953 are Allee, long at Chicago, now at the University of Florida, Carter at Illinois, Cope at Mass. Institute of Technology, DuBridge at California Institute of Technology, Noyes at Rochester, Reichelderfer, Chief of the U. S. Weather Bureau, Lee Smith at Minnesota, Homer Smith at New York University, Stanley at California (Berkeley), Stone at Stanford, Urey at Chicago, Werkman at Iowa State (Ames), Cleland, Muller and Sonneborn at Indiana University, Skinner at Harvard. The two Noyes and two Termans are father and son.

Of the National Academy members, Indiana University graduated (college degree) Mann, Riddle, Slipher, Stone, L. Terman, and Wissler; Earlham graduated Allee and Stanley and started Urey; Butler graduated Cope; DePauw graduated Carter; Purdue graduated Purcell and Werkman; and Manchester College graduated Paul J. Flory (b. 1910), physical chemist, at Cornell University.

Sketches of these men are given in Visher: *Indiana Scientists* (Indiana Academy of Science, 1951), and in Who's Who in America.

Dr. John T. Plummer (1807-1865), Pioneer Scientist of Richmond, Indiana

LAWRENCE J. KING, Boyce Thompson Institute, and
M. S. MARKLE, Earlham College

More than a century ago in the "American Journal of Science" for 1844, a young physician of Richmond wrote:

"To know the bareness of a locality in reference to geographical distribution is as desirable to a naturalist as the knowledge of the fruitfulness of another district. Especially has it appeared to me to be desirable that lists of the reptiles, insects, fishes, plants, etc., of the newly settled sections of the country should be made out, not only for present purposes, but for the future student of nature who may traverse the same regions when highly populated and improved, and the influence of terrestrial cultivation on wild organic nature be determined. Impressed with this view, I have for years past directed my attention to the animal and vegetable kingdoms around me, and have been endeavoring to perfect catalogs of their several subjects."

Such was the introduction to a list of the Mollusca of the vicinity of Richmond by Dr. John Thomas Plummer. The paper was the first regional list of molluscs for the state of Indiana and was the last one in the series of "catalogs" published in that journal. The author makes clear here, with remarkable foresight, the plans and purposes of his studies in the natural history of the county.

In the published histories of Indiana science little attention has been given to the life and work of Dr. Plummer. His pioneer researches in the natural history of Wayne County and the investigations in many other phases of science and scholarship have long remained hidden in now obscure publications. An extensive search into the leading scientific and agricultural journals of that period has revealed a long series of writings, a bibliography of which comprises some one hundred fifty-two titles.

Though Dr. Plummer was widely known among his contemporaries, his pioneer efforts have lacked recognition generally. In 1916, in connection with the Indiana State Centennial, the Indiana Academy of Science published several histories of the development of the sciences within the state, including botany, geology and zoology. In these accounts, Dr. Plummer's contributions were almost entirely overlooked.

Probably the major portion of his published writings have now been located; and while they have revealed many facts of his life, the biographical details are all too few. Memorials published after his death and in particular the excellent account by Dr. James F. Hibberd (Lancet-Clinic, 8:384-389, 1865), have been the major sources of biographical data. Aside from the one notebook referred to later, none of the unpublished writings, letters, etc. of Dr. Plummer have been located. The present account deals more specifically with his scientific contributions, since they are best known to the writer at the present time.

Dr. Plummer was a descendant of one of the early colonists, Thomas Plummer, of Prince George County, Maryland, born about 1772. The

former was born in Montgomery County, Maryland, March 7, 1807, the son of Joseph Pemberton Plummer and Susannah Husband Plummer. Born into the Society of Friends (Quakers) he was placed after his mother's death in 1816 in Nine-Partner's Boarding School in New York. In 1819 Joseph Plummer, his second wife, Lydia Husband, and four children, Sarah, Mary, Joanna, and John, moved to Cincinnati. In 1823 they moved to Richmond, Indiana, where Joseph Plummer established a general store.

The great beauty of the Whitewater country, with its vast tracts of virgin forests and native wild life and the massive beds of exposed rock, representing eons of geological history, undoubtedly made deep impressions on young John, then sixteen years of age. In that first year of residence in the community he noted down his observations on weather, etc., which were published many years later. Thus began a long and distinguished scientific career.

During those first years he was employed as a clerk in his father's store. He was not successful as a clerk, for "he was constantly found with a book in his hand in which he was profoundly absorbed, while the patrons of the store came and went with a minimum of attention, or none at all." One amusing story has come down to us from his granddaughter, Frances Rachel Anderson, who has written, "It is recorded that when a woman customer asked to see some calicoes, Grandfather, without looking up, handed her a foot or yard rule and said, 'If thee will point out which one thee wants, I will be glad to get it down.' "

From work in the store he turned to the study of medicine, "reading" with Dr. Thomas Griffith, a prominent practitioner of Richmond. We have his own note concerning his entrance into the profession of medicine: "I commenced reading medicine on the 20th day of Tenth Month, 1825; may my principal aim be the good of my fellow man; let not fame nor wealth be desired." In 1827, after two years of study with Dr. Griffith, he entered the medical school of Yale University, graduating from there in 1828 at the age of twenty-one.

The course of study pursued for the medical degree was of such a generalized nature that he surveyed practically all the sciences. The greatest single influence in the development of his scientific career was probably that of one of his teachers, the eminent scientist, Dr. Benjamin Silliman, professor of chemistry and natural history at Yale from 1802 to 1853. Dr. Silliman founded the American Journal of Science, to which Dr. Plummer contributed a number of articles in later years. A friendship began there which was to last for many years. In 1828 Dr. Plummer learned his chemistry, pharmacy, mineralogy and geology from Dr. Silliman and his botany and materia medica from Dr. Eli Ives.

While he was at Yale he met the distinguished Noah Webster, whom later he was to aid in the preparation of his dictionary of the English language. Still in existence is one of Dr. Plummer's notebooks used in medical school, entitled, "Necessaria, Richmond, Ia. 1827 Jno. Tho. Plummer." While the book is miscellaneous in nature, it contains a rather detailed account of his trip from Richmond to New Haven, Conn., in 1827; an expense account of the trip and of his stay at New Haven; together

with lecture notes in botany, chemistry, geology, medicine and law. His habit of meticulous note-taking and keen observation are very evident in this notebook. This is perhaps the first of a series of notebooks kept throughout the remainder of his life, and, unfortunately, is the only one still known to exist. We can only surmise as to the contents of the others from the several accounts which were published.

On the basis of his broad training in medicine and the sciences and his contacts with great scientists, he was well prepared when he returned to Richmond in 1828 to practice medicine and to attempt an understanding and an interpretation of the natural history of the region. As it has been to many others since, the great region of the upper Whitewater indeed presented a challenge to this young physician. While his first years were spent in devotion to his medical practice, he nevertheless kept records of the weather, the seasons and vegetational changes, bird migrations, etc., as early as 1823. According to present knowledge his first writings probably appeared in the "Family Schoolmaster" in 1839. His first technical article, "The Effects of Light on Vegetation," was published in the Indiana Farmer in 1840.

Richmond in 1833, with a population of 1,740 (3,000 in 1840) had six physicians. Among the physicians of that early period two personalities stand out—Dr. Ithamar Warner and Dr. John T. Plummer. Both made notable contributions to the life of the community. Dr. Plummer served for thirty-seven years and established a reputation as a learned and skilled physician. Because of his training and experience in chemistry and pharmacy, he was often consulted as an analyst in medico-legal cases. In 1838 he was a member of the Richmond Board of Health. In all his activities he was rather reserved and did not seek prominence nor fame; and it is recorded that he declined several offers of teaching positions in medical schools. He belonged to few organizations, neither to the Indiana State Medical Society nor to the American Medical Association. He was, however, made an honorary member of the Cincinnati Horticultural Society in 1844 and in late years a correspondent of the Boston Society of Natural History.

Dr. Plummer was stockholder and the first president of the Richmond Gas, Light and Coke Company in 1855. The Interstate History states, "Being so thoroughly devoted to scientific and literary studies, he took but little part in public business. He had decided views on political questions, but always declined to participate in any political movements, or to cast a vote for any candidate, who, if elected, might be required to use force in the discharge of his official duties."

Dr. Plummer was a keen observer and rather meticulous in noting down observations and bits of information he encountered. His notebooks were filled with accurate and extensive observations and from these he prepared many articles for publication. He also seems to have kept rather complete medical records. His medical writings are clearly expressed and are models of accuracy and good English usage. According to present records he published about seventeen articles of a strictly medical character in the journals of the time. His first article, "Animlcula discovered in the dejections of cholera patients," was published in the Western

Lancet in 1849. His last contribution was one of a series entitled, "Diseases of Richmond, Wayne County, Ind." and was published in the Cincinnati Medical Observer for 1856. Some of these medical journals, inscribed with his name and bearing corrections in his handwriting, are preserved in the John Crerar Library in Chicago.

In addition to medical writing he also contributed twenty-seven papers on chemistry and pharmacy, the latter appearing in the Journal of Pharmacy from 1851 to 1859. Dr. Plummer's knowledge of pharmacy, chemistry and botany were put to good use, for he grew some of his medicinal plants and prepared many of his medicines. For many years Dr. Plummer's residence and office in Richmond were located on Fort Wayne Avenue, between Cliff and Sassafras Streets. In 1852 Dr. Plummer and Dr. W. P. Waring were associated in joint practice. In the same year they opened a drug store.

While maintaining a practice in the city for many years, with the purchase of a farm in 1834 by Joseph Plummer, John Thomas seems to have spent considerable time at the farm, which was located in the area now known as Reeveston. This life offered many opportunities for study and experimentation in the many new methods then being developed in agriculture. His many views and observations on prevailing methods and his experiments with plants and insects are to be found in several of the leading agricultural periodicals, mostly between 1840 and 1847, in the Indiana Farmer, Indiana Farmer and Gardner and the Western Cultivator.

Several early articles on the botany of the county and of the state appeared during these years in the agricultural journals. In 1842 he published a list of twenty-one species of grasses growing in the vicinity of Richmond, giving their technical names together with data on their habitats and distribution. This seems to be the first paper on grasses for any region in the state of Indiana and one of the very earliest contributions to the flora of the state. His next list, published in 1845, contained fifty-two species of the more "ornamental" shrubs and trees of the vicinity of Richmond. His more extensive list of the trees and shrubs of the county comprising nearly 200 species was that included in 1847 in his review of Emerson's book. These are only a few of his many writings on plant life; the others include studies on germination and the influence of light and temperature on crop plants, fruits, etc. Additional plant records are to be found in Dr. Plummer's copy of John Torrey's "A Compendium of the Flora of the Northern and Middle States" (New York, 1826). Here he has checked 536 species as occurring in the Richmond area and 251 are indicated as being found on the Plummer farm.

His finest scientific writings, however, were the series of "catalogs" published in the American Journal of Science. The first, "Suburban Geology, or Rocks, Soil and Water, about Richmond, Wayne County, Indiana," a paper of thirty-three pages, published in 1843, was the first contribution to the geology of the county. Aside from T. A. Conrad's description of some Richmond Fossils in 1842, Dr. Plummer's is the first known list from the Richmond area. He discussed the geography and geology in some detail, with lists of some forty species of fossils. There

were fourteen figures, including maps, diagrams and drawings of fossils. He was first to observe and describe glacial striations in this region, finding them on limestone at Thistlethwaite's Falls, north of Richmond. He found seven mounds near Richmond. In 1823 he opened one, finding a human skeleton, with fragments of wood, coal, Indian corn, a smooth piece of ivory and the bones of some animal. He concluded that the mounds were of human origin, not geological formations, as was then currently believed.

His study of the mammals of the county, the second in the series of "catalogs," was a paper of fourteen pages, published in 1844, is of special interest because of its descriptions and historical data of animals no longer found in the county. He lists forty-three species of mammals. An elk was killed near Richmond in 1811. Horns were still found in the woods. Elkhorn Creek was named because of the number of these horns found on its banks. A black bear was killed very near Richmond in 1824. Porcupines and gray foxes were still found. A new species of mouse, Arvicola riparius, was described. Some of these observations were noted by M. W. Lyon in his "Mammals of Indiana," 1936.

His third paper, of four pages, published in 1845, the last of his "catalogs," surveyed the molluscs of the county. The list of animals was extended in 1851 by the publication of a recording of twenty-two species of fishes.

These early papers on the fauna and flora of the county are invaluable as records of many species existing a century ago, but no longer found. These records would have increased value if specimens from his extensive museum and herbarium had been preserved. About the time that the Plummer family moved to Chicago, it is probable that the plant collection was given to Purdue University. One specimen, that of the Seneca snakeroot, *Polygala Senega*, is still a part of the Stanley Coulter Herbarium at Purdue University. It is the oldest known plant specimen from Wayne County.

Dr. Plummer was a leader in the Society of Friends (Quakers), holding many important positions of responsibility. He was especially interested in the education of young Friends, having been a teacher of botany and astronomy in Green Mount Boarding School. He founded and edited The Family Schoolmaster, the earliest literary paper printed in Richmond, a small quarto, begun in 1839, to "amuse and interest the young." It was discontinued with the thirty-fourth number. No copies are known, though articles were reprinted in the Richmond Palladium, including one reviewing the photographic work of Daguerre, of Paris.

He helped to found the Richmond Athenaeum, concerned with the study of art, literature and the sciences. The rooms of the society housed a library and museum. In 1839, he was critic and curator of the museum. He noted in 1841 the discovery near Richmond of a mastodon tooth and huge tusk, which were placed in the museum of the society. He also had his own private collection.

The work for which Dr. Plummer is best known locally is his "Reminiscences of the History of Richmond," a part of the City Directory of

1857. From his personal experiences and from records then current he compiled significant information that would otherwise have been lost.

In his work in Quaker education he prepared three Readers for children, selecting material conforming to the principles of the Society of Friends. Copies of the First and Second Readers are known to exist.

In 1833 Dr. Plummer married Hanna Wright, of Springboro, Ohio. They had one son, Jonathan Wright Plummer (1835-1918). After the death of his first wife, he married Sarah O. Pierce, of Portsmouth, N. H. They had three children, all of whom died relatively young. Sarah Plummer died in 1877. Joseph W. Plummer became a minister in the Society of Friends and actively promoted the work of the group. He was a wholesale druggist in Chicago, later moving to Glencoe, Ill. A daughter, Mary W. (1856-1916), was a well-known author of verse and of books for children and prominent in the American Library Association and the New York Public Library. A son, John Thomas Plummer II, lived in Denver, Colo., until his death in 1943. A daughter, Frances Plummer Anderson, lives in Dorset, Vt.

After much suffering from acute rheumatism, Dr. Plummer died on April 10, 1865. Of the many tributes published at the time, the one in the Richmond Palladium of April 13, 1865 is here quoted:

"With the citizens of Richmond, Dr. Plummer has been closely and familiarly identified for the past forty years. In all that time he has gathered to himself lasting friends. As a physician, skilled in his profession, few were his superiors. He was always a hard worker, mentally, and whatever his mind prompted him to do he did with all his might. We believe he was a true Christian, full of kindly charity. He was a consistent and life-long member of the Society of Friends. On Wednesday last his remains were followed from the Friends Meeting House by one of the largest processions of sorrowing relatives and friends we have witnessed for years."

As a devoted Friend, as a skillful physician and as a naturalist and scholar of the first rank, Dr. Plummer deserves recognition as one of the most distinguished of Richmond's public servants and as one of the great pioneer scientists of the state of Indiana.

MATHEMATICS

Chairman: ARTHUR ROSENTHAL, Purdue University

RALPH HULL, Purdue University, was elected chairman for 1954

ABSTRACTS

Quadratic forms in vector spaces. EBERHARD HOPF, Indiana University.—A quadratic form in a vector space is defined by a bilinear form in that space. Every quadratic form satisfies a certain functional equation—the parallelogram identity. There is the converse question whether every solution of this functional equation is a quadratic form or not. The answer is no, but under very mild additional conditions of boundedness or measurability the answer is shown to be yes.

A property of integrals of the product of the Lagrange interpolating polynomials and the exponential function. DONALD B. OWEN, Purdue University.—A simple set of integral rational fractions with integral coefficients which estimate the exponential function may be obtained from the integrals indicated in the title. By combining certain of these estimates additional estimates may be obtained such that the polynomials in the numerator and denominator differ only in that the signs of the terms alternate in the denominator whereas they are all positive in the numerator. One such estimate is given by

$$\exp(x) = (12 + 6x + x^2)/(12 - 6x + x^2),$$

which is accurate to seven decimal places for $-0.1 \leq x \leq +0.1$. Six terms of the power series expansion are needed to give this accuracy. Other estimates are even more accurate. Approximations of this type may be useful in high speed computing where storage of information is a problem.

Some convergent sub-series of the harmonic series. HOWARD K. HUGHES, Purdue University.—If from the series $\sum_{n=1}^{\infty} \frac{1}{n}$ one omits every term whose denominator contains a given digit, say 9, in any manner, the remaining terms form a series which converges. In case 9 is used, the sum is less than 23.

On the concept of continuity of functions f(x,y). ARTHUR ROSENTHAL, Purdue University.—The continuity of a single-valued function $f(x,y)$ at a point $p_0 = (x_0,y_0)$ can be characterized by means of the continuity of f along certain classes of curves through p_0. In this respect the following result is obtained: If f is continuous at p_0 along every curve through p_0 which is (at least) once continuously differentiable, then f is also continuous at p_0 as a function of (x,y). Yet f can be continuous along every

curve through p_0 which is (at least) twice differentiable without being continuous at p_0 as function of (x,y).

Remarks on graduate study in mathematics. RALPH HULL, Purdue University.—A brief discussion of some of the problems associated with graduate study in mathematics, from a departmental point of view, and with particular emphasis upon the problem of selecting and counselling Ph.D. candidates.

Some problems and results of additive number theory. PAUL ERDOS, Notre Dame University.—Let $0 < a_1 < a_2 < \cdots$ be an infinite sequence of integers. Denote by $f(n)$ the number of solutions of $n = a_i + a_j$. Turán and the author conjectured that if $f(n) > 0$ for all sufficiently large n then lim sup $f(n) = \infty$. This conjecture seems very difficult to prove. Another conjecture of theirs is the following: Let $a_1 < a_2 < \cdots$ be an infinite sequence of integers. Then for every constant c

$$\limsup \left| \sum_{k=1}^{n} f(k) - c\,n \right| = \infty.$$

About twenty years ago Sidon asked the author if he could construct a sequence of integers so that, for all n, $f(n) > 0$ but $f(n)/n^{\epsilon} \to 0$, for all $\epsilon > 0$. Recently the author succeeded in proving the existence of such a sequence. In fact his sequence satisfies $f(n) < c \log n$.

The general solution of some linear partial differential equations with constant coefficients. MICHAEL GOLOMB, Purdue University.—The general solutions, in the sense of all solutions from a specified function class, are known only for very few partial differential equations. A solution of this problem for the equation $P(\partial/\partial x, \partial/\partial y)u = 0$, where $P(\xi,\eta)$ is an arbitrary homogeneous polynomial with constant coefficients, recently established by Adam Schmidt, is extended to equations of the same form, where $P(\xi,\eta)$ is no longer homogeneous, but is a product of arbitrary linear and quadratic factors, and to equations of the form $P(\partial/\partial x, \partial/\partial y)u = f(x,y)$.

On the asymptotic stability of solutions of nonlinear differential equations of parabolic type. R. NARASIMHAU, Indiana University.—A sufficient condition is obtained for the asymptotic stability of the zero solution of the nonlinear parabolic differential equation,

$$U_t = \sum_{i,j} Aij\, U_{x_i x_j} + \sum_{i} b_i\, U_{x_i} + F(x,t,u)\,;\ i,j = 1,2,\cdots,n.$$

The result is extended to systems of such equations and under more restrictive assumptions, to the case where $F = F(x,t,u,u_x)$. The above results include as special cases the existing theorems on stability of parabolic differential equations.

Sampling distribution of ranges from an arbitrary discrete population. IRVING W. BURR, Purdue University.—Use and importance of the range as a measure of variability in small samples is steadily growing. A method is given for finding the exact sampling distribution for any discrete population with finite range. It depends upon certain combinations of the n'th

powers of sums of consecutive probabilities. The calculations are quite feasible for samples of five or less, if the population probabilities are taken to the nearest .01 or .005.

The hydraulic pendulum. C. TRUESDELL, Indiana University.—The work of Newton and other early writers on the motion of a finite amount of water in a curved tube has been incorporated in elementary texts. More important, but apparently little known, is Euler's determination of the cavitation criteria for these motions, for if the pressure falls to zero the dynamical solution becomes illusory. Euler's method is entirely general. Here it is applied to the motion of a section of water of arbitrary length in a circular tube. When the pressure remains positive, it is obvious that the motion is that of an appropriate equivalent simple pendulum. Necessary and sufficient conditions for the pressure to remain positive are obtained.

Discussion of a state-wide mathematics competition. LESTER H. LANGE, Valparaiso University.—An annual mathematics competition for mathematics students in the colleges of Indiana was sponsored by the Mathematics and Physics Club of Valparaiso University in the spring of 1953. A report on that competition is given and it is proposed to discuss the desirability of such a competition and to enlist the aid of all the colleges in both the formulation of the examination and the encouraged participation of their students.

PHYSICS

Chairman: R. E. WINN, Purdue University

GEORGE D. VAN DYKE, Earlham College, was elected chairman for 1954

ABSTRACTS

What is the origin of induced electromotive force? FRANCIS E. THROW, Wabash College.—Is the fundamental cause of electromagnetic induction a cutting of lines of force, a change in B, or a change in the flux linkages? A demonstration is arranged to make the familiar appear strange, the true appear doubtful, and the false appear plausible.

Inelastic scattering of alphas by N^{14}.* BYRON M. CARMICHAEL, Indiana University.—N_2 gas at 0.075 atmos. pressure has been bombarded with 21.5 m.e.v. alpha particles from the cyclotron, and the alpha groups from the reaction N^{14} (α, α') N^{14*} have been analyzed with the magnetic spectrometer at angles of 90° and 105.5°. Levels in N^{14} at 3.95, 5.09, 5.80, 6.46 and 7.02 m.e.v. are found from the Q values of the alpha groups. No alpha group leading to the 2.3 m.e.v. level established by other reactions was observed. It is estimated that a group of intensity 2% of the ground state intensity would have been detected. It has been predicted that this level should not be excited in the reactions N^{14} (α, α') N^{14*}, (d, d') N^{14*}, and O^{16} (d, α) N^{14*} since isotopic spin conservation would be violated.[1] The non-excitation of this level by the latter two reactions has been reported by other observers.[2,3]

* Supported in part by the joint program of ONR and AEC.

1. R. K. ADAIR, Phys. Rev. 87, 1041 (1952).
2. BROWNE, BOCKLEMAN, BEUCHNER and SPERDUTO, Bull. Am. Phys. Soc. 28, No. 1, 11 (1953).
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The Indiana University Heavy Particle Spectrometer[1]

V. K. Rasmussen, D. W. Miller, M. B. Sampson and B. M. Carmichael,
Indiana University, Bloomington, Indiana

A large magnetic spectrometer, copied after those at the California Institute of Technology (1), has been built. The magnetic field is shaped to give point focusing in the manner introduced by Siegbahn (2). Limiting the magnetic field to π radians instead of $\sqrt{2}\,\pi$ radians puts the source and image outside the field, which is convenient.

This spectrometer is used to measure the energy spectra of the protons, alpha-particles, etc. that result from nuclear reactions induced by the external beam of the Indiana University cyclotron. A target chamber with a sliding O-ring seal allows the spectrometer to be rotated so that all angles with the beam from a minimum of 10° to a maximum of 45° counter clockwise and 145° clockwise are available.

The scattering of 22 Mev alpha-particles by carbon has been investigated. The elastic alphas and groups corresponding to inelastic scattering leaving C^{12} excited to known levels 3 at 4.31, 7.7, and 9.6 Mev are observed. The search for groups corresponding to higher excitations is difficult because of the continuous distribution of alpha's from $C^{12} \rightarrow Be^{8} + \alpha$, $Be^{8} \rightarrow 2\,\alpha$. Some indication of a level around 12.7 Mev is obtained. Any other states between 9.6 Mev and the upper limit of around 16.1 Mev must be excited much less easily than the 9.6 level.

At the forward angles the recoil C^{12} nuclei have enough energy ($>$ 8 Mev) to penetrate the window of the proportional counter used as a detector. Ground state C^{12}'s as well as those that have been excited to the 4.4 Mev level are observed. None corresponding to excitation to the 7.7 or 9.6 Mev levels are observed, indicating that these levels decay to $Be^{8} + \alpha$ (threshold excitation $=$ 7.37 Mev). Additional experiments are required before definite statements as to the competition between this process and decay to the ground state of C^{12} by radiation can be made. It would seem, however, that it is very improbable for the 9.6 Mev level to decay by radiation to the C^{12} ground state (as is expected), and that the 7.7 Mev level decays in this manner less than 50 $\pm$ 50) % of the time.

Literature Cited

1. Snyder, Rubin, Fowler, and Lauritsen, *Rev. Sci. Inst.*, **21**, 852 (1950).
2. K. Siegbahn and N. Svartholm, *Nature*, **157**, 872 (1946).
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1. Supported in part by the joint program of ONR and AEC.

Construction of Thermocouples

D. M. Sutter and J. E. Brock, Purdue University

The classic equation for the transient flow of heat in a given direction X in any medium is

$$\frac{\partial t}{\partial \tau} = \alpha \frac{\partial^2 t}{\partial x^2} \qquad (1)$$

where t is temperature, τ is time, and α is a constant characteristic of the medium and called the thermal diffusivity. In order to evaluate heat flow by means of equation (1) it becomes necessary to evaluate the rate of change of temperature both with respect to time and with respect to position. When steep front thermal transients of large amplitude are measured in the laboratory, thermocouples are usually employed that have small thermal capacity to secure the greatest sensitivity and small size to fix the position at a point. This paper has been prepared with the experiences in mind of assembling large numbers of thermocouples having small thermal capacity, and at the same time strong enough to withstand the stresses of high pressures and shock. The claims are not so much for new methods as for the possible improvement of old techniques.

Three methods of constructing thermocouples that have been found useful are described herein. Apparatus for each of the methods was constructed from items commonly found in every research laboratory.

Mercury Pool Welder. The circuit for this welder was arranged as shown in Figure 1. The small glass vessel—a 30 ml. beaker—was filled to a depth of one-half inch or more with mercury. About one-fourth inch of lubricating oil floating on top of the mercury prevented splashing and resulted in cleaner welds. Power for welding was obtained from a 110 volt power outlet. To make a thermocouple, the ends of the wire were twisted together and then connected to one side of the 110-volt power line at A. The heat generated by the arc formed when the twisted ends contacted the mercury accomplished the welding. Excellent welds were obtained with all kinds of base metal thermocouple wires smaller than about #20 gaugs, with this welder.

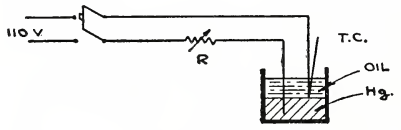

FIG. 1 CIRCUIT DIAGRAM FOR THE MERCURY POOL WELDER

Spark Welder. This welder was constructed according to the circuit shown in Figure 2. When the switch was thrown to position 1, the condensers C(300-900 mf) were charged to a potential of 100 volts or more through the rectifier X. When the switch was thrown to position 2 and the two thermocouple wires (T.C.) were quickly brought together, the

energy in the arc produced a butt weld. In order to secure a good weld it was found necessary to grind the ends of the wires flat. The wires were positioned to meet end to end by clamping them to the wooden blocks B,B which were constrained to move in a straight line by guides.

This welder was also found to be useful for attaching thermocouples to many kinds of surfaces. The jig carrying the blocks B,B was removed and connections to the surface were made at P. The thermocouple to be attached to the surface is connected at Q. When the condensers were charged and the thermocouple junction brought into contact with the surface, a weld occurred and the thermocouple was firmly attached to the surface. Obviously the method doesn't work well when the surface has a high thermal diffusivity.

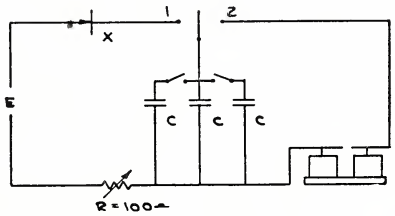

FIG. 2 CIRCUIT DIAGRAM FOR THE SPARK WELDER

Concentric Assembly. Recently a thermocouple has been developed in which one element was an oxidized wire threaded through a length of small tubing which forms the second element. The inside diameter of the tube and the diameter of the wire were very nearly the same. The tubing was then stretched until it contracted firmly around the wire. A thermal junction was formed by grinding and polishing the end of the assembly and then plating the end with any desired metal. The oxide coating on the inner wire served to insulate it from the surrounding tube. An iron-constantan thermocouple made from #30 gauge constantan wire and a small bore iron tube will have a time constant of the order of microseconds when the plating forming the junction is about one micron thick.

In order to form the oxide coating on the constantan wire enough current from the 110-volt line was passed through it to bring it to a dull red heat. After about fifteen minutes of heating in the open a heavy oxide coating would be formed on the wire. This oxide coating gave an insulation resistance of several megohms between the wire and outside tube before the junction was formed.

A jig for assembling the thermocouple is shown in Figure 3. The outer tube (T) was fastened to the blocks (b) by means of soft solder and the oxidized wire threaded through the tube. The blocks (b), constrained to move in guides, were moved by means of the screws (s) and the tube stretched and contracted until it gripped the inner wire firmly. A resistance measurement was indicative of when the tube had contracted securely around the wire, i.e., the resistance before stretching being 200 megohms or more and dropping to about 20 megohms when stretching

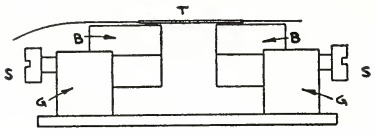

FIG. 3 JIG FOR CONCENTRIC TUBE THERMOCOUPLE ASSEMBLY

ceased. The tube was then annealed and removed from the jig. Thermocouples made in this manner have withstood the stresses of high fluid pressures and the shock of vibrating mechanisms.

Conclusion

Three methods for making thermocouples from small wires have been described. One of the methods has been especially useful for constructing thermocouples having high sensitivity and also resistance to shock and pressure.

ZOOLOGY

Chairman: W. H. JOHNSON, Wabash College
JOHN D. MIZELLE, University of Notre Dame, was elected chairman for 1954

ABSTRACTS

Some problems in the sterile culture of *Paramecium*. WILLIS H. JOHNSON, Wabash College.—Problems encountered in the sterile culture of *Paramecium*, beginning with the original work in 1942 down to the present, are discussed. The original studies indicated that autoclaved medium would not support growth of this ciliate. The first sterile culture was established in a medium of proteose peptone containing filter sterilized pressed yeast juice. The yeast juice had two essential fractions—one heat labile and one heat stable. The heat labile fraction could be substituted for by using cytidylic and guanylic acids. Many attempts to substitute known substances for the heat stable fraction have been unsuccessful. It is possible to use the chemically known medium of Kidder for *Tetrahymena*, minus Tween, plus a small amount of the heat stable yeast fraction and obtain good growth of *Paramecium*. Attempts are now being made to isolate the essential material in the yeast by fractionation.

Activities of subterranean animals as revealed by injecting their tunnels with liquid latex. MURVEL R. GARNER, Earlham College.—The technique of injecting the tunnels of small soil invertebrates with liquid latex, for the study of their tunneling activities, has been described previously before this body. Some of the activities of animals, especially in relation to the modification of soil, are considered.

Earthworms are instrumental in bringing soil from the lower horizons to the surface; and ants drop nibbled bits of soil from the A horizon into the lower levels. Thus there is a continual, systematic interchange of soil materials in the vertical tunnels of small animals.

The effects of various concentrations of ions on the asexual reproduction of *Aeolosoma*. FRED I. KAMEMOTO and CLARENCE J. GOODNIGHT, Purdue University.—Studies on the effects of the inorganic ions Ca, K, and Mg, on the asexual reproduction of the annelid *Aeolosoma sp.* have been carried on.

Knop's solution ($Ca(NO_3)_2$, KNO_3, $MgSO_4$) was used as the base of the culture medium. The concentrations of the salts were varied by increasing the amount of one salt while decreasing the concentration of another, and keeping the third at a constant. Total concentrations used were from 0.01-0.05%. The solutions were buffered with a phosphate buffer and the experiments were carried on at various constant temperatures.

Preliminary results seem to indicate that calcium has the greatest effect on the reproductory rate of these animals. There also seems to be

an importance in the relative concentrations of the calcium and magnesium ions.

The ciliary antigenic system of stock 32, variety 4, of *Paramecium Aurelia.* T. M. SONNEBORN and FRANCES R. OGASAWARA, Indiana University.—Stock 32 of variety 4 of *Paramecium aurelia* includes nine diverse hereditary serotypes characterized by the possession of nine different ciliary antigens, A, B, C, D, E, G, H, K, and M. Each serotype is subjected to five different temperatures (31°, 27°, 19°, 13°, 10°C) while growing in two different media (Difco lettuce and Cerophyl) after a brief exposure to specific antiserum and also without such exposure. From the study of these 180 different combinations of serotypes and conditions, the following relations emerge. Though most serotypes can be maintained or obtained at more than one temperature, each serotype has a characteristic optimum temperature range for maximum stability and frequency of origin. Most serotypes are less stable in Cerophyl than in Difco lettuce, but B is more stable in Cerophyl. Exposure to specific antiserum increases the frequency of transformation for all serotypes except M, which is actually more stable after such exposure. Each serotype is characterized by specifiable optimal combinations of conditions for origin, stability, and transformation, thus permitting full experimental control. Of great importance in understanding this system is the fact that identical treatment and external conditions induce somewhat different transformations when applied to different serotypes.

The interpretation of larval types in the trematode family Fellodistomatidae. R. M. CABLE, Purdue University.—As usually classified, cercariae now regarded as larval fellodistomatids may be trichocercous, microcercous, furcocerous with or without setae, or even tail-less (cercariaea). In all types, however, the morphology of the body is very similar and development occurs in simple sporocysts in bivalve mollucks. Microcercous and tail-less larvae are readily explained as examples of caudal reduction and loss associated with curtailment of free-living activity of the larvae. Since this explanation cannot be invoked in interpreting other larval types in the family, a study has been made to determine which of them, the trichocercous or furcocercous type, is a modification of the other. Observations on trichocercous larva developing in *Laevicardium mortoni* in the Woods Hole region indicate that the furcocercaria is the basic larval type in the family and that the trichocercous form has arisen by the acquisition of caudal setae and loss of the furcae without a corresponding reduction of the tail stem. This conclusion is supported by the existence of trichofurcocercous forms and the embryology of the excretory system in the trichocercous species studied at Woods Hole.

Nuclei that fail to transmit genes, a result of exposure to ultraviolet in *Paramecium aurelia.* MYRTLE V. SCHNELLER, Indiana University.—After self-fertilization (autogamy) among the cells descended from an irradiated individual, subnormal cultures develop. These have been isolated, cultured, and analyzed genetically. When mated to normal cultures, known to differ in certain genes, the genes of the progeny are found to come exclusively from the normal parent. This would lead one to guess

that the abnormal parent had no genes to transmit; in other words, that the result of exposure to ultraviolet had been the destruction of the nuclei. This is, however, not the case. The nuclei are present, multiply during fission, and undergo meiosis during conjugation. However, during the later stages of conjugation these nuclei all disintegrate and disappear; so only the nuclei of the normal mate give rise to the nuclei in the exconjugants. Certain consequences of this erratic behavior will be pointed out.

The biology and affinities of the Bivesiculidae (Trematoda: Digenia). LLOYD A. LEZOTTE, JR., Purdue University.—Six species of furcocystocercous cerceriae found to develop in marine snails are evidently larvae of the family Bivesiculidae. The cercariae develop in rediae in the branchial region of the snail and are similar to fresh-water azygiid cercariae. The right and left halves of the excretory system in the cercaria do not fuse either in the body or tail, thus resulting in the paired excretory vesicles of the adult. The cercarial excretory pattern is much simpler than that of the Azygiidae.

There evidently is no second intermediate host, the cercaria being eaten by a fish and developing to maturity in the intestine. Whether or not the life cycle in the Bivesiculidae requires a second intermediate host, there can be no question that these cercariae are the larvae of that family because of the complete agreement between the cercarial stage and the adult which are unique among the Digenea.

In the light of this study, the family Bivesiculidae, formerly associated with the Monorchiidae, is less closely related to that group than to the Azygiidae. The development of the simpler larva of the Bivesiculidae suggests that it is intermediate to the cyathocotylid and azygiid larvae and supports the allocation of both the Bivesiculidae and the Azygiidae to the order Strigeatoidea La Rue.

The Terrestrial Isopods (Oniscoidea) of Indiana[1]

William R. Eberly, Indiana University[2]

The purpose of this paper is two-fold. First, since the isopods of Indiana are little-known, and there is no list of isopods of the state, it seemed desirable to list the species known to occur in Indiana as well as a few that might be expected to occur. In the second place, since the distribution of any animal or plant is important in the study of its biology and ecology, the distribution records of these species is given as far as known at the present time. Many of the species listed here may prove to be state-wide in their distribution. Finally, a key is included for the identification of the forms included in this paper.

The literature on the isopods is extensive, but scattered. The two most significant American works are those of Richardson (1905) and Van Name (1936), including the two supplements to the last named work (1940 and 1942). Van Name has attempted to bring together the descriptions and distribution records of all land and fresh-water isopods of the Western Hemisphere. It is, therefore, a good compilation of the pertinent information in the literature up to 1942.

The writer has collected isopods chiefly as a spare time activity. The main collection points have been around Bloomington and Winona Lake. These two places give a fair idea of the southern and northern distribution. No claim is made that the following list includes all of the land isopods of the state. Extensive collecting in other areas will undoubtedly turn up other species. Van Name suggests (1936, p. 37) that "95 per cent of the land isopods that will come to the notice of the ordinary observer in most parts of the United States or Canada will belong to one or another of [these] 8 species . . .": *Oniscus asellus*, *Porcellio scaber*, *Porcellio spinicornis*, *Porcellionides pruinosus*, *Cylisticus convexus*, *Tracheoniscus rathkei*, and *Armadillidium vulgare*. All of these, he states, are old world species that have been introduced into America by human agencies and have spread across the continent with the expansion of civilization.

Five of these species have been collected by the author and are included in the present paper. The other three have been reported from adjacent states and may possibly occur in Indiana. *Oniscus asellus* is reported from Rock Island, Illinois (Richardson, 1905), and from the state of Michigan (Hatchett, 1947). It is rather common in the East, especially in the New England area. It might occur in the northern part of the state. It is one of the larger isopods and may be distinguished by the three joints in the flagellum of the antennae. *Porcellio laevis* is quite widespread and has been reported from Cincinnati, Ohio (Richardson, 1905). It might occur in the southern part of the state. *Porcellio spinicornis* has been reported recently from Michigan (Hatchett, 1947) and might occur in the northern part of the state.

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1. Contribution No. 542 from the Department of Zoology, Indiana University.

2. The writer wishes to thank Dr. Sears Crowell for his assistance in the preparation of this manuscript.

Previous Indiana Records

Only four species of the present list have been reported for Indiana by earlier authors. In 1873 Packard described a new form from "Indiana" which he called *Euphiloscia elrodii*. Hay (1891) lists this as the only "sow-bug" described from the state, although he mentions that several species are common. Packard's description is vague and the type locality is uncertain, but it is thought that his species is identical with *Ligidium longicaudatum* Stoller (see Van Name, 1936, p. 76, and 1940, p. 134). If this could be proven, Packard's specific name would have priority over *longicaudatum*, since the latter was applied by Stoller (1902) 29 years later. In this paper the writer has assumed the synonomy but has used the later nomenclature in the absence of conclusive evidence regarding the identity of Packard's isopod. Davis (1951) has recorded *L. longicaudatum* from a sphagnum bog near Bloomington in Monroe County.

In 1899 Hay described a new species of "subterranean isopod," *Haplophthalmus puteus*. It is generally conceded to be identical with the previously described *H. danicus*. Hay collected "40 or 50 specimens" from an old well near Irvington in Marion County.

Blatchley (1896) listed one specimen from Wyandotte Cave which he referred to the genus *Porcellio*. It was probably *Porcellio scaber*. This species was listed by Banta (1907) as an inhabitant of Mayfield's Cave in Monroe County. It was also reported by Evermann and Clark (1918) to be common around Lake Maxinkuckee in Marshall County.

The last species is *Tracheoniscus rathkei* (formerly *Porcellio rathkei*). This is recorded by House (1910) from Winona Lake in Kosciusko County. Hatch (1939) also reports this species from Winona Lake.

To my knowledge, the records listed above represent the only reports of any of the Oniscoidea in the fauna of Indiana.

In the following list of Indiana species, the reader is referred to certain pages in Richardson (1905) and Van Name (1936) where complete descriptions of each of the species may be found. For an understanding of the various terms used in describing isopods one may turn to either of the above named works (especially Van Name) or to an earlier work of Richardson (1904).

LIST OF SPECIES

Family Ligiidae

1. *Ligidium longicaudatum* Stoller.
   Richardson (1905), p. 689.
   Van Name (1936), p. 70.
   Localities—Kosciusko County; Monroe County.

This species may be distinguished from other Indiana isopods by the flagellum (terminal portion) of the large second antennae, which has 12 to 15 segments. No other species in Indiana has more than 6 or 7. It frequents damp or wet places (most often near some body of water) under leaves and rocks. It moves very rapidly and is difficult to capture.

Family Trichoniscidae

2. *Trichoniscus demivirgo* Blake.
Richardson (1905), p. 694 (as *T. pusillus*).
Van Name (1936), p. 78.
Locality—Monroe County.

This is a small species (4-5 mm.) that prefers damp places under stones and leaves. It moves rapidly (as do most of the members of this family). It is a reddish-brown color with a darker brown reticulation. The eyes consist of three ocelli which, in my specimens, are so closely grouped together that it is difficult to distinguish them.

3. *Trichoniscus* species.
Locality—Monroe County.

The writer has one small specimen (2.75 mm.) from the Cascades Park in Bloomington. It was secured under an old stump in a moderately dry situation. It belongs to the subgenus *Miktoniscus* (see Van Name, 1936, p. 87) which is distinguished from other groups in the genus *Trichoniscus* by having only a single ocellus and having the back covered with tubercles. It bears some differences from any of the species of *Miktoniscus* described from America. It is white, or nearly so, in the living condition and can be distinguished from *Haplaphthalmus danicus* (the only other tiny white isopod now known from Indiana) by the position of the tubercles on the back. In this species the generally acute tubercles are arranged in more or less transverse rows while in *H. danicus* the tubercles are blunt (sometimes reduced to continuous raised ribs or ridges) and arranged in longitudinal rows.

4. *Haplaphthalmus danicus* Budde-lund.
Richardson (1905), p. 697 *(H. puteus)*.
Van Name (1936), p. 90.
Localities—Fulton County; Kosciusko County; Marion County (Hay, 1899); Marshall County; Monroe County.

This tiny, white isopod, about 3 to 4 mm. long, is not as commonly seen as its wide distribution would seem to indicate. Perhaps they are often overlooked because of their size by people who think they might be just the young ones of other common species with which they are found. They frequent moist soil under boards and logs.

Family Oniscidae

5. *Porcellio scaber* Latreille.
Richardson (1905), p. 621.
Van Name (1936), p. 226.
Localities—Clay County; Kosciusko County; Marshall County (Evermann & Clark, 1918); Monroe County; Wabash County.

This is a large isopod, varying from 10 to 15 mm. in length. It has many conspicuous tubercles scattered over the back, two segments in the flagellum of the antennae, and its color is generally a uniform black or slate gray, but sometimes may be mottled with brown. It has respiratory tubes (trachea) in only the first two pairs of abdominal plates.

6. *Porcellionides pruinosus* Brandt.
Richardson (1905), p. 627 *(Metaponorthus pruinosus).*
Van Name (1936), p. 238.
Localities—Kosciusko County; Monroe County; Wabash County.

This is a medium sized (9 to 10 mm.) isopod, dusty gray to reddish-gray in color, that may be distinguished by the two segments in the flagellum of the antennae and the fact that the abdomen is abruptly narrower than the thorax. The proximal joint of the flagellum is supposed to be twice the length of the distal segment, but in my specimens it varied from being equal in length to almost twice in length. This isopod appears to be able to withstand the driest conditions of any that the writer has collected. One was found in the dust under some rocks at a limestone quarry near Bloomington and several were found in the dust in the basement of a house in Wabash County.

7. *Cylisticus convexus* De Greer.
Richardson (1905), p. 609.
Van Name (1936), p. 259.
Localities—Kosciusko County; Lagrange County; Marshall County; Monroe County; Wabash County.

This common isopod is one of the few that can roll themselves into a ball. It may be distinguished from the two species of *Armadillidium* (the others of Indiana that can roll themselves into a ball) by the presence of long, pointed uropods projecting from the posterior end of the body. In the genus *Armadillidium* the uropods are broad and do not project beyond the rounded outline of the posterior end of the body. *Cylisticus convexus* is gray, with rows of light patches along each side of the body, and reaches a length of 12 mm. or so.

8. *Tracheoniscus rathkei* Brandt.
Richardson (1905), p. 617 *(Porcellio rathkei).*
Van Name (1936), p. 262.
Localities—Brown County; Clay County; Fulton County; Kosciusko County; Lagrange County; Marshall County; Monroe County; Wabash County.

This is perhaps the commonest isopod of Indiana. It is spread over much of the eastern United States. It has trachea in all five pairs of abdominal appendages. Its color is somewhat variable, ranging from gray to brown, with three rows of light patches along the back. The back has some low tubercles on it. The average length is about 12 mm.

Family Armadillidiidae

9. *Armadillidium vulgare* Latreille.
Richardson (1905), p. 666.
Van Name (1936), p. 276.
Localities—Kosciusko County; Monroe County.

This species and the following one can roll themselves up into a perfect little ball, with no part of their body projecting outward. From this habit they have been given the name of "pill bugs." They are large, reaching nearly 15 mm. in length. The color varies from dull gray to

light brown. *A. vulgare* has a wide range but its occurrence locally may be restricted. It prefers living under logs and boards in semi-dry conditions.

10. *Armadillidium nasatum* Budde-lund.
Richardson (1905), p. 668 *(A. quadrifrons).*
Van Name (1936), p. 279.
Localities—Brown County; Monroe County.

This species is almost identical with *Armadillidium vulgare.* It may be distinguished by the large, squarish lobe which projects forward directly from the middle of the head. There is a notch in the middle of the margin of the head where it connects with this lobe. Sometimes the projecting lobe of the epistome is not so prominent, but the notch in the margin of the head is always there.

Key to the Species Now Known from Indiana

1. a. With 2 segments in the flagellum of the antennae.....2
   b. With more than 2 segments in the flagellum of antennae.....7
2. a. Uropods long and pointed, projecting from the rear of the body...3
   b. Uropods short, broad and truncate, forming part of the outline of the rounded posterior end of the body.....6
3. a. Body highly convex in cross-section, capable of rolling into a ball, *Cylisticus convexus.*
   b. Body more or less depressed; not capable of rolling into a ball....4
4. a. Abdomen abruptly narrower than thorax, *Porcellionides pruinosus.*
   b. Abdomen not abruptly narrower than thorax.....5
5. a. Trachea in only the first 2 pairs of abdominal appendages; body highly tuberculate, *Porcellio scaber.*
   b. Trachea in all 5 pairs of abdominal appendages; body only slightly marked with low tubercles, *Tracheoniscus rathkei.*
6. a. Front margin of head entire, not surpassed by epistome, *Armadillidium vulgare.*
   b. Front margin of head with a small, v-shaped notch; epistome projecting beyond head as a large, squarish lobe, *Armadillidium nasatum.*
7. a. With 12 to 15 segments in the flagellum of the antennae, *Ligidium longicaudatum.*
   b. With 4 to 7 segments in the flagellum of the antennae.....8
8. a. Lateral parts of abdominal segments flared out and separated from each other; longitudinal ridges or rows of tubercles on the back; small; white, *Haplophthalmus danicus.*
   b. Lateral parts of abdominal segments bent down and in close contact with each other, making the abdomen appear narrower than the thorax 9
9. a. Body more or less smooth, with tiny setae scattered about; larger; reddish-colored, *Trichoniscus demivirgo.*
   b. Body thickly covered with rather acute tubercles arranged in more or less transverse rows; small; white, *Trichoniscus (Miktoniscus)* sp.

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Notes on the Hatching of the Black Racer
Coluber constrictor

GERTRUDE L. WARD, Earlham College

A clutch of 14 **Coluber constrictor** eggs was found July 20, 1953, by a man plowing a field south of Richmond, Ind. They were in sandy loam, buried approximately 8 inches below the surface, and in nearly the same place that similar eggs were found by the same man in 1951 and 1952.

In the laboratory, the eggs were kept under moistened paper toweling in a terrarium containing 2 inches of soil. The bulb in a gooseneck lamp about 9 inches above the eggs was kept lit between 8 a. m. and 6 p. m. each day to provide heat. Six black racers hatched from Aug. 26 to 27.

Of the remaining 8 eggs, 2 were deeply dented when found, and they were opened Aug. 8. The yolk was still quite moist. One shell was occupied by a male, the other by a female. Heartbeat and blood circulation through the vitelline vessels was evident in both. The male measured 18 cm. and the female was slightly smaller. The hemipenes of the male were exserted. Both specimens were preserved.

In the entire study, the snakes were weighed on a Welch triple beam platform scale, and measured by stretching until there were no spasmodic contractions of the body. Each snake was stretched on a piece of plain paper on a flat surface, and pencil marks were made by an assistant at the tip of the nose and tail. The marked distance was then measured.

On Aug. 29, 2 days after the sixth snake had emerged, the remaining 6 eggs were cut open. All of the young, 3 males and 3 females, were dead and the yolk remaining in the shells was dry and hard.

The measurements of these snakes are as follows, to the nearest centimeter: males, 29 (hemipenes exserted), 23 (1 hemipenis exserted), 22 (hemipenes inverted); females, 27, 24 (no eyeballs), 23.

All of these snakes were shorter than the shortest snake which hatched, which measured 30 cm. No egg teeth were seen on any of these snakes nor on the ones which hatched successfully.

One possible explanation for the eyelessness of one snake which did not hatch is offered by Lynn and Ullrich. They produced shell abnormalities and eyelessness experimentally in turtles by exposing the eggs to suboptimal moisture conditions for a few days during the period from the 35th to the 50th day of development.

The first snake to hatch did so the morning of Aug. 26 and escaped the incubator. It was found dead Sept. 2. A female, it measured 30 cm. The weight was not taken.

Number 2, a female, was born Aug. 26, weighing 12.09 grams and measuring 35 cm. She is not known to have eaten and on Oct. 27 weighed 5.35 gr., and measured 39 cm.

Number 3, another female, weighed 4.32 grams when hatched Aug. 26, and measured 31.3 cm. She refused toads, mealworms, grasshoppers and a new-born dead mouse, and died Sept. 12.

Number 4, a male, was born Aug. 27, when it weighed 9.26 gr. and measured 34 cm. On Oct. 27 it weighed 5.68 gr. and measured 39 cm.

Number 5, a female, weighed 8.6 gr. at hatching Aug. 27 and measured 34 cm. She shed Oct. 12, and was seen to eat a small cricket Oct. 19. Like the others, she also lost weight, weighing 5.77 gr. Oct. 27, when she measured 39 cm.

Number 6, a male, weighed 6.72 gr. at hatching Aug. 27, and measured 30 cm. It refused food and died Sept. 13.

The snakes were distinguished from one another by the differences in the dorsal saddle-shape markings.

The young emerged through longitudinal slits in the tough shells. In one shell there were 2, and in another, 3 parallel slits varying in length from 1 to 2 cm. The snakes emerged from the longer slits in these instances.

In two shells, the slits were observed to be open as long as 13 hours before the actual emergence of the young snake. One young snake, coiled in the shell, would alternately show its rostral plate at the opening, then its left eye. Breathing was evident as bubbles of amnionic fluid would expand and contract at the slit.

Number 3 was observed at 5:20 p. m. Aug. 26 with two-thirds of its body protruding from the shell. It struggled by throwing its body from side to side at two or three minute intervals. It struck several times with its mouth open, then wiggled its body out another few millimeters. The whole body came through at 5:40 p. m. with the observer bending the shell slightly, thus widening the opening.

Dangling from the umbilical opening was about 2 inches of yolk sac. The snake dragged this about as it roamed the terrarium. After 3 or 4 minutes, it slid between a small clod of dirt and the glass wall, dragging more of the sac out of its body until the vitelline vessels could be seen. Finally the yolk sac dragged enough that the vessels parted and the sac was left behind.

Viewing the interior of the other 5 shells, yolk sacs were seen within 4 of them. It seems probable that the yolk sac is sometimes ejected as the snake leaves the shell, by rubbing against the lower edge of the slit.

On the other hand, Number 6 had drawn up the yolk sac into the abdomen, which textbooks mention as customary in birds and reptiles. There is no obvious correlation between retention of the yolk sac and birth weight.

The three remaining snakes have been kept in a terrarium 39 by 19 by 16 inches, planted with ferns, hepatica, stonecrop and mosses. One 1½-inch salamander *(Ambystoma tigrinum)* and a rough green snake *(Opheodrys aestivus)* also inhabit the terrarium. Young toads (*Bufo* sp.) were present for from 3 to 4 weeks, then were removed when there was no evidence of feeding by the Colubers.

Such invertebrates as sow bugs, crickets, small grasshoppers and earthworms were placed in the terrarium in the hope that the snakes would feed on them. Feeding was observed only once, when number 5 ate one of the crickets. Force feeding with beaten egg was started Nov. 5 and carried on to date, Nov. 12.

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A Quantitative Study of Thyroxin—Thyrotropic Hormone Interaction[1]

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The problem of finding a suitable biological assay for thyroid stimulating hormone (TSH) in body fluids is complicated by the report that endogenous thyroid hormone has an inhibitory effect on TSH (Aron, 1930; Loeb, Bassett and Friedman, 1930; Loeser, 1934; Cortell and Rawson, 1944). D'Angelo and Gordon (1950) report, however, that the stasis tadpole technique for assay may be used to detect simultaneously both thyroxin and TSH, since TSH increases the thyroid cell height, while thyroxin causes an accelerated hind limb growth. The two effects reportedly are additive, indicating that one is not affected by the other. Recently, however, Steinmetz (1951) has shown by factorial analysis, using the original data of D'Angelo and Gordon, that there is interaction with inhibition between TSH and thyroxin in the stasis tadpole. The present report is an attempt to study quantitatively the interaction between TSH and thyroxin.

Methods

Day old White Leghorn male chicks were used. They were kept in groups of 20-25 in compartments of standard chick "Pullman" boxes without food or water for the duration of the experiment. Different series were distinguished by coloring the head and back with colored dyes. Ten animals were allotted to each series. The chicks were injected twice a day for 3 days in the cervical region with varying doses of TSH[2] or thyroxin[3] in ½ ml. amounts, or with combinations of the two hormones. Controls were injected with ½ ml. of physiological saline. At the end of the 3 day injection period, the animals were sacrificed, and the thyroids were removed quickly, cleaned of non-thyroidal tissue, and weighed on a torsion balance to the nearest 0.02 mg. The glands were then fixed in 10% formalin for sectioning. Five μ sections were cut from five of the glands of each series and the tissues were stained with Azan stain. Ten sections scattered throughout the gland were chosen at random for reading, and one cell from a distinct follicle at the edge of each section, and one cell from the middle of each section was measured with a filar micrometer at a magnification of 1470 times.

The doses of thyroxin used (1, 5, 10 μgm) were chosen because Odell (1952) reported that 10.3 μgm equivalents of D-L thyroxin were secreted per day by 40-day-old White Leghorn cockerels. The thyroxin used in these experiments was L-thyroxin, which is the physiologically active isomer of the thyroid gland, and thus, is about twice as active as the mixture. The 5 μgm dosage should, therefore, be more than sufficient for the chicks.

1. Contribution No. 541 from the Department of Zoology, Indiana University.
2. USP Thyrotropin reference standard. Each mg. represents 0.05 USP Thyrotropin units.
3. Squibb crystalline D-thyroxin.

Results

Analysis of variance was the statistical treatment used to analyze the interactions between TSH and thyroxin. The cell heights in the various series are presented in table I. The acinar cells of the thyroids of the control series averaged 1.75 μ in height. The cells of the thyroids which received 0.01 USP units of TSH averaged 1.80 μ in height. This was a non-significant increase. The chicks which received 0.025 and 0.05 USP units of TSH had cell height averages of 2.08 μ and 5.01 μ respectively, and both increases were significant at the 1% level, as determined by "t" test. The thyroids of the birds receiving thyroxin averaged 1.96, 1.57, and 1.58 μ respectively for dosages of 1, 5, and 10 μgms of thyroxin. The 1 μgm dose caused cell height increases which were significantly greater than the controls, while the 5 and 10 μgm doses caused significant cell height decreases.

TABLE I. Thyroid cell heights of chicks treated with TSH and thyroxin, alone and in combination.[4]

Thyroxin – μgms. \ TSH – USP units	0	0.01	0.025	0.05	Sum	Mean
0	1950 1.75μ	2004 1.80μ	2313 2.08μ	5569 5.01μ	11836	29.59
1	2176 1.96μ	1878 1.69μ	4506 4.06μ	5469 4.92μ	14029	35.07
5	1738 1.57μ	1697 1.53μ	4361 3.92μ	5955 5.36μ	13751	34.38
10	1757 1.58μ	1787 1.60μ	3739 3.36μ	5072 4.56μ	12355	30.89
Sum	7621	7366	14919	22065	51971	
Mean	19.05	18.42	37.30	55.16		129.93

4. The upper figure is the sum of the readings for each group. These figures were not converted to microns for greater ease in handling calculations. The lower figure in each group is the mean cell height in microns.

TABLE II. Analysis of Variance. Thyroxin – TSH data.

Source of Variation	d.f.	Sum of Squares	Mean Square
Thyroxin	3	8483.88	2827.96**
TSH	3	366330.43	122110.14**
Interaction	9	27316.41	3035.16**
Error	1584	57932.75	36.57
Total	1599	460063.47	

The analysis of variance in table II shows that thyroxin and TSH both have a significant effect on the bird's thyroids, and also that there is an interaction between thyroxin and TSH. This is most striking in the third column where 0.025 units of TSH was administered. Here the thyroxin appears to have a synergistic effect in combination with TSH as shown by the increased cell heights of the thyroids receiving the combined hormones over those thyroids which received TSH alone. All other doses of TSH plus thyroxin show a decrease in cell height as the thyroxin is increased, with the one exception of the 0.05 units of TSH plus 5 μgm of thyroxin series where the cell height is again increased significantly over that of the 0.05 unit TSH series cell heights.

Discussion

Fugo (1940) reports that the chick anterior pituitary becomes active during late embryonic stages, and that TSH is being released at the time of hatching. The amount of TSH must be very small, however, since sections of normal 4-day-old chick thyroids show follicles which are distended with colloid, and have squamous epithelial cells with darkly staining pycnotic nuclei. Both conditions are indicative of an inactive thyroid. Breneman (1941), and Payne (1942) report that the day-old chick, under starvation conditions, has an anterior pituitary which is nearly or completely inactive. We are thus using the equivalent of a hypophysectomized animal for a biological assay. Cortell and Rawson report no change in thyroid cell height in hypophysectomized rats treated with thyroxin, but since thyroxin caused a decrease in the cell height in chicks, it appears likely that the day-old assay birds are releasing minute quantities of TSH. This amount, however, is insufficient to cause much activation of the thyroid gland.

The TSH injected birds (Row 1) show no significant increase in cell height between 0 and 0.01 TSH units, whereas there is a significant increase in cell height when 0.025 units are given and a very sharp increase in cell height between 0.025 and 0.05 units of TSH. It appears that the threshold level for TSH lies between 0.01 and 0.025 units. A series of graded doses of TSH between these levels should be run to determine the amount of TSH which serves as the threshold level.

Two important points stand out in the thyroxin injected series. First, the injection of thyroxin at the 1 μgm level causes an increased cell height. This is contrary to the conclusions of Cortell and Rawson, and others, that administration of thyroxin causes a decrease in cell height of the thyroid. The higher doses of thyroxin, however, give the expected decrease in cell height. The second point to be noted is that there is a synergistic action between 0.025 units of TSH and the various dosages of thyroxin.

There are two possible explanations for these results. (1). Since the chicks are without food or water from the time of hatching until they are sacrificed at 4 days, the general body metabolism is undoubtedly decreasing. Injection of a low dosage of thyroxin may cause an increase in the cellular metabolism of the thyroid without producing inhibition. TSH, therefore, may be more effective and may stimulate the thyroid, thus producing greater cell height. Measurement of cellular metabolism of the

thyroids would help determine the correctness of this hypothesis. (2). Cellular metabolism of the pituitary also may be increased by injection of thyroxin. With an increased metabolism, the pituitary may release more TSH, which in turn would produce greater stimulation of the thyroid. If this hypothesis is correct, one might also expect to find an increase in other pituitary hormones. This could be checked by comparing weights of other endocrine organs, and by direct assay of the pituitaries.

Summary

Day-old White Leghorn male chicks were injected with varying doses of thyroxin or TSH, or combinations of the two. Cell height measurements of the thyroids showed that 1 μgm of thyroxin caused increased cell height instead of the expected decrease. It was also found that 0.025 USP units of TSH, in combination with thyroxin caused cell height increases, indicating synergistic action between the hormones. Other combinations of the hormones caused decreased cell heights. Two possible explanations are given for these results. (1). Increased thyroid cellular metabolism, or (2). increased pituitary cellular metabolism, with increased TSH production.

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